

Env 1000



Environment
Canada

Environnement
Canada

Canada - Ontario Agreement on Great Lakes Water Quality



Ontario

Ministry
of the
Environment



CA2 ON
EV.309

R097
c.2

Storm Water Management Model Verification Study

Research Report No. 97



**Research Program for the Abatement of Municipal Pollution
under Provisions of the Canada-Ontario Agreement
on Great Lakes Water Quality**

Copyright Provisions and Restrictions on Copying:

This Ontario Ministry of the Environment work is protected by Crown copyright (unless otherwise indicated), which is held by the Queen's Printer for Ontario. It may be reproduced for non-commercial purposes if credit is given and Crown copyright is acknowledged.

It may not be reproduced, in all or in part, for any commercial purpose except under a licence from the Queen's Printer for Ontario.

For information on reproducing Government of Ontario works, please contact ServiceOntario Publications at copyright@ontario.ca

CANADA-ONTARIO AGREEMENT

RESEARCH REPORTS

These RESEARCH REPORTS describe the results of investigations funded under the Research Program for the Abatement of Municipal Pollution within the provisions of the Canada-Ontario Agreement on Great Lakes Water Quality. They provide a central source of information on the studies carried out in this program through in-house projects by both Environment Canada and the Ontario Ministry of Environment, and contracts with municipalities, research institutions and industrial organizations.

The Scientific Liaison Officer for this project was Mr. D.G. Weatherbe, Ontario Ministry of Environment.

Enquiries pertaining to the Canada-Ontario Agreement RESEARCH PROGRAM should be directed to -

Wastewater Technology Centre
Canada Centre for Inland Waters
Environment Canada
P.O. Box 5050
Burlington, Ontario L7R 4A6

Ontario Ministry of Environment
Pollution Control Branch
135 St. Clair Avenue West
Toronto, Ontario M4V 1P5

STORM WATER MANAGEMENT
MODEL VERIFICATION STUDY

by

M.M. Dillon Ltd.
Toronto, Ontario

RESEARCH PROGRAM FOR THE ABATEMENT
OF MUNICIPAL POLLUTION WITHIN THE
PROVISIONS OF THE CANADA-ONTARIO
AGREEMENT ON GREAT LAKES WATER QUALITY

Project No. 74-8-5

This document may be obtained from -

Training and Technology Transfer
Division (Water)
Environmental Protection Service
Environment Canada
Ottawa, Ontario
K1A 1C8

Ontario Ministry of the Environment
Pollution Control Branch
135 St. Clair Avenue West
Toronto, Ontario
M4V 1P5

REVIEW NOTICE

This report has been reviewed by the Technical Committee of the Canada-Ontario Agreement on Great Lakes Water Quality and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of either the Ontario Ministry of the Environment or Environment Canada, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

© Minister of Supply and Services Canada 1979

Cat No. En43-11/97
ISBN 0-662-10752-7

Kromar Printing Ltd.
Contract No. 02KT KE204-9-0580

ABSTRACT

The report describes the main aspects of a study to calibrate and verify the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM) for an urban catchment area. Details of the selected area, the instrumentation used, and of the results obtained are presented and discussed. The data obtained from selected storm events are compared with simulated hydrographs and pollutographs generated by the SWMM. It is concluded that these simulations of real storm events, with respect to both runoff flow and water quality, are very good when compared to those obtained in other studies.

RÉSUMÉ

Le présent rapport décrit les principaux aspects de l'étalonnage et de la vérification du modèle SWMM (Storm Water Management Model) de l'agence américaine de protection de l'environnement (EPA), appliqué à un bassin récepteur urbain. A cette fin, il décrit la région choisie, les instruments utilisés et les résultats obtenus. Les données, enregistrées lors de certains orages, sont comparées aux courbes simulées d'hydrographie et de pollution produites par le modèle. En ce qui a trait à l'écoulement et à la qualité de l'eau, ces simulations se sont révélées très fidèles, comparativement à celles obtenues au cours d'autres études.

TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	i
TABLE OF CONTENTS	iii
List of Tables	v
List of Figures	vi
1. INTRODUCTION	1
2. DESCRIPTION OF THE URBAN CATCHMENT AREA	2
2.1 Geographical Characteristics	2
2.1.1 Size and location	2
2.1.2 Topography	2
2.1.3 Land Use	2
2.1.4 Population	2
2.2 Hydrologic Characteristics	6
2.3 Drainage System	6
2.3.1 Roof and foundation drainage	6
2.3.2 Road gutters	8
2.3.3 Catch basins	8
2.3.4 Sewer pipes	8
2.4 Municipal Practices	8
2.4.1 Street cleaning	15
2.4.2 Sewer cleaning	15
2.4.3 Snow and ice control	15
3. INSTRUMENTATION AND DATA ACQUISITION	21
3.1 Introduction	21
3.2 Installation and Location of Data Acquisition System	21
3.3 General Weather Data	24
3.3.1 Temperature measurement	24
3.3.2 Precipitation measurement	25
3.3.3 Data obtained	25
3.4 Measurements of the Runoff	26
3.4.1 Flow measurement	26

TABLE OF CONTENTS (CONT'D)

	<u>Page</u>
3.4.2 Water quality measurements	29
3.4.3 Data obtained	32
4. SIMULATIONS USING THE STORM WATER MANAGEMENT MODEL	35
4.1 Introduction	35
4.2 Division of the Urban Catchment Area	35
4.3 Calibration	39
4.3.1 Quantity calibration	39
4.3.2 Quality calibration	48
4.4 Verification	53
4.4.1 Quantity verification	54
4.4.2 Quality verification	61
5. CONCLUDING COMMENTS	63
ACKNOWLEDGEMENT	65
APPENDIX A - Monthly Summaries of Temperature and Precipitation	69
APPENDIX B - Rainfall Data	77
APPENDIX C - Hydrographs and Pollutographs	81
APPENDIX D - Runoff Quality Data	95
APPENDIX E - Dry Weather Flow Quality Data	105

LIST OF TABLES

<u>Table</u>		<u>Page</u>
1	Approximate Distribution of Existing Land Use Within Urban Test Area	4
2	Street Cleaning within Study Area During 1976	16
3	Street Cleaning within Study Area During 1977	17
4	Salting of Roads within Study Area During 1975/76 Winter	19
5	Road and Sidewalk Ploughing Within Study Area During the 1975/76 Winter	19
6	Snow Removal from Within Study Area During the 1975/76 Winter	20
7	Precipitation-Runoff Events Monitored for Quantity and Quality	23
8	Summary of Snow Survey Reports	27
9	Daily and Hourly Dry Weather Flow Variations	34
10	Subcatchment Data	36
11	Runoff Block Pipe Data	39
12	Transport Block Sewer Element Data	40
13	Results of Attempts to Calibrate Input Parameters Relating to Pervious Areas	46
14	Quality Input Data	49
15	Variable Quality Input Parameters	50
16	Quality Subcatchment Data	51
17	Comparison of Simulated and Recorded Flow Volumes	55
18	Comparison of Simulated and Recorded Peak Runoffs	57
19	Comparison of Simulated and Recorded Times to Peak	59

LIST OF FIGURES

<u>Figure</u>		<u>Page</u>
1	Urban Test Area	3
2	Existing Land Use	5
3	Gross Residential Density of Population	7
4	Aerial Photo	9
5	Standard Pavement Cross Section	11
6	Catch Basin Details	12
7	"As Built" Sewer Plan	13
8	Schematic of Data Acquisition System	22
9	Details of Weir Plates	28
10	Position of Weir Plates	30
11	Weir Rating Curve	31
12	Dry Weather Flow Variations	33
13	Map Showing Subdivision of Catchment Area	37
14	Comparison of Recorded and Simulated Runoff - Storm of June 25, 1976	43
15	Precipitation Volume vs. Recorded Volume	45
16	SWMM Verification Results - Simulated vs. Recorded Volume of Runoff and DWF	56
17	SWMM Verification Results - Simulated vs. Recorded Peak Runoff	58
18	SWMM Verification Results - Simulated vs. Recorded Time to Peak	60

FIGURES PRESENTED IN APPENDIX C

<u>Figure</u>		<u>Page</u>
Ia	Comparison of Recorded and Simulated Hydrograph- July 7, 1976	81
Ib	Comparison of Recorded and Simulated BOD - July 7, 1976	81
Ic	Comparison of Recorded and Simulated SS - July 7, 1976	81
IIa	Comparison of Recorded and Simulated Hydrograph - March 27, 1976	81
IIb	Comparison of Recorded and Simulated BOD - March 27, 1976	81

FIGURES PRESENTED IN APPENDIX C (CONT'D)

<u>Figure</u>	<u>Page</u>
IIc Comparison of Recorded and Simulated SS - March 27, 1976	81
IIIa Comparison of Recorded and Simulated Hydrograph - March 31, 1976	81
IIIb Comparison of Recorded and Simulated BOD - March 31, 1976	81
IIIc Comparison of Recorded and Simulated SS - March 31, 1976	82
IVa Comparison of Recorded and Simulated Hydrograph - April 22, 1976	82
IVb Comparison of Recorded and Simulated BOD - April 22, 1976	82
IVc Comparison of Recorded and Simulated SS - April 22, 1976	82
Va Comparison of Recorded and Simulated Hydrograph - April 25, 1976	82
Vb Comparison of Recorded and Simulated BOD - April 25, 1976	82
Vc Comparison of Recorded and Simulated SS - April 25, 1976	82
VIa Comparison of Recorded and Simulated Hydrograph - May 11, 1976	82
VIIb Comparison of Recorded and Simulated BOD - May 11, 1976	83
VIIc Comparison of Recorded and Simulated SS - May 11, 1976	83
VIIa Comparison of Recorded and Simulated Hydrograph- June 1, 1976	83
VIIb Comparison of Recorded and Simulated BOD - June 1, 1976	83
VIIc Comparison of Recorded and Simulated SS - June 1, 1976	83
VIIIa Comparison of Recorded and Simulated Hydrograph - June 20, 1976	83
VIIIb Comparison of Recorded and Simulated BOD - June 20, 1976	83
VIIIc Comparison of Recorded and Simulated SS - June 20, 1976	83
IXa Comparison of Recorded and Simulated Hydrograph - June 30, 1976	84
IXb Comparison of Recorded and Simulated BOD - June 30, 1976	84
IXc Comparison of Recorded and Simulated SS - June 30, 1976	84

FIGURES PRESENTED IN APPENDIX C (CONT'D)

<u>Figure</u>		<u>Page</u>
Xa	Comparison of Recorded and Simulated Hydrograph - July 1, 1976	84
Xb	Comparison of Recorded and Simulated BOD - July 1, 1976	84
Xc	Comparison of Recorded and Simulated SS - July 1, 1976	84
XIa	Comparison of Recorded and Simulated Hydrograph - July 1, 1976	84
XIb	Comparison of Recorded and Simulated BOD - July 1, 1976	84
XIc	Comparison of Recorded and Simulated SS - July 1, 1976	85
XIIa	Comparison of Recorded and Simulated Hydrograph - July 2, 1976	85
XIIb	Comparison of Recorded and Simulated BOD - July 2, 1976	85
XIIc	Comparison of Recorded and Simulated SS - July 2, 1976	85
XIIIa	Comparison of Recorded and Simulated Hydrograph - July 11, 1976	85
XIIIb	Comparison of Recorded and Simulated BOD - July 11, 1976	85
XIIIc	Comparison of Recorded and Simulated SS - July 11, 1976	85
XIVa	Comparison of Recorded and Simulated Hydrograph - July 20, 1976	85
XIVb	Comparison of Recorded and Simulated BOD - July 20, 1976	86
XIVc	Comparison of Recorded and Simulated SS - July 20, 1976	86
XVa	Comparison of Recorded and Simulated Hydrograph - July 29, 1976	86
XVb	Comparison of Recorded and Simulated BOD - July 29, 1976	86
XVc	Comparison of Recorded and Simulated SS - July 29, 1976	86
XVIa	Comparison of Recorded and Simulated Hydrograph - July 31, 1976	86
XVIb	Comparison of Recorded and Simulated BOD - July 31, 1976	86
XVIc	Comparison of Recorded and Simulated SS - July 31, 1976	86
XVIIa	Comparison of Recorded and Simulated Hydrograph - August 13, 1976	87

FIGURES PRESENTED IN APPENDIX C (CONT'D)

<u>Figure</u>		<u>Page</u>
XVIIb	Comparison of Recorded and Simulated BOD - August 13, 1976	87
XVIIc	Comparison of Recorded and Simulated SS - August 13, 1976	87
XVIIIa	Comparison of Recorded and Simulated Hydrograph - September 1, 1976	87
XVIIIb	Comparison of Recorded and Simulated BOD - September 1, 1976	87
XVIIIc	Comparison of Recorded and Simulated SS - September 1, 1976	87
XIXa	Recorded Runoff - December 6, 1975	87
XIXb	Recorded BOD - December 6, 1975	87
XIXc	Recorded SS - December 6, 1975	88
XXa	Recorded Runoff - December 9, 1975	88
XXb	Recorded BOD - December 9, 1975	88
XXc	Recorded SS - December 9, 1975	88
XXIa	Recorded Runoff - December 30, 1975	88
XXIb	Recorded BOD - December 30, 1975	88
XXIc	Recorded SS - December 30, 1975	88
XXIIa	Recorded Runoff - January 26, 1976	88
XXIIb	Recorded BOD - January 26, 1976	89
XXIIc	Recorded SS - January 26, 1976	89
XXIIIa	Recorded Runoff - March 5, 1976	89
XXIIIb	Recorded Runoff - March 5, 1976	89
XXIIIc	Recorded BOD - March 5, 1976	89
XXIIId	Recorded SS - March 5, 1976	89
XXIVa	Recorded Runoff - April 6, 1976	89
XXIVb	Recorded BOD - April 6, 1976	89
XXIVc	Recorded SS - April 6, 1976	90
XXVa	Recorded Runoff - May 6, 1976	90
XXVb	Recorded BOD - May 6, 1976	90
XXVc	Recorded SS - May 6, 1976	90

FIGURES PRESENTED IN APPENDIX C (CONT'D)

<u>Figure</u>		<u>Page</u>
XXVIa	Recorded Runoff - May 6, 1976	90
XXVIb	Recorded BOD - May 6, 1976	90
XXVIc	Recorded SS - May 6, 1976	90
XXVIIa	Recorded Runoff - July 16, 1976	90
XXVIIb	Recorded BOD - July 16, 1976	91
XXVIIc	Recorded SS - July 16, 1975	91
XXVIIIa	Recorded Runoff - August 28, 1976	91
XXVIIIb	Recorded BOD - August 28, 1976	91
XXVIIIc	Recorded SS - August 28, 1976	91
XXIXa	Comparison of Recorded and Simulated Hydrograph - June 25, 1977	91
XXIXb	Comparison of Recorded and Simulated Hydrograph - June 29, 1977	91
XXIXc	Comparison of Recorded and Simulated Hydrograph - August 10, 1977	91

1. INTRODUCTION

In response to recent concerns over the pollution caused by surface runoff and combined sewer overflows, an Urban Drainage Subcommittee was established under the Canada-Ontario Agreement on Great Lakes Water Quality to carry out a research program for the abatement of municipal pollution. Included in the research program were field data collection studies intended to yield information on the quantity and quality of runoff from Canadian watersheds with which to calibrate, verify and continue the development of urban hydrologic simulation models, as well as aiding in problem definition. This report describes one such study carried out on an urban catchment in Metropolitan Toronto.

The terms of reference for the study can be summarized as follows:

- i) Selection of urban catchment area between 100 and 2000 acres in size in Metropolitan Toronto, served by combined sewers.
- ii) The design, installation and operation of a data acquisition system to monitor temperature, precipitation and the quantity and quality of runoff.
- iii) Collection and presentation of data required for the verification of the Storm Water Management Model (SWMM).
- iv) The calibration and verification of the Runoff and Transport blocks of SWMM for both quantity and quality, using a maximum of 20 well-defined storm events.

This study presents the results of work carried out between November 1, 1975, and December 31, 1977. Information concerning the urban catchment area, its drainage system, the municipal practices, and the design and installation of the data acquisition system were presented in detail in an earlier unpublished report, dated March 1976, entitled "Storm Management Model Verification Study". Pertinent information from this earlier document is included in the present report in order to make it a self-contained document.

The requirements that the urban catchment be served by combined sewers with preferably one outlet for ease of instrumentation, and that the chosen sewer system be well documented so that it could be readily modelled, resulted in only two moderately suitable catchment areas being identified. This apparent lack of suitable areas in Metropolitan Toronto is a direct result of the fact that the city and most of its boroughs are in the process of partially separating their sewers. The urban catchment area selected is situated in the Borough of East York.

2.1 Geographical Characteristics

2.1.1 Size and location

The urban catchment area is a drainage basin located approximately four miles to the northeast of downtown Toronto in the Borough of East York. As may be seen from Figure 1 it is approximately rectangular in shape, and can be described as being roughly bounded by Cosburn Avenue, Cedarvale Avenue, Milverton Boulevard and Donlands Avenue. The catchment has an area of 383 acres.

2.3.2 Topography

The general surface of the catchment area slopes gently towards the lowest elevation of 388.5 ft at the junction of Queensdale Avenue and Linsmore Crescent. The highest ground elevation is 436.5 ft in the northeast corner of the catchment area at the junction of Dunkirk Road and Woodmount Avenue.

2.1.3 Land use

The details of the land-use divisions are presented in Table 1, and their spatial distribution is shown in Figure 2. The area is predominantly residential (89.1%), the overwhelming majority of which comprises single-family units. Institutional (5.7%), parks and open spaces (4.2%), and commercial (1.0%) areas make up the remainder.

2.1.4 Population

Census of Canada's figures show that the population in the study area decreased between 1951 and 1966, possibly as a result of a maturing

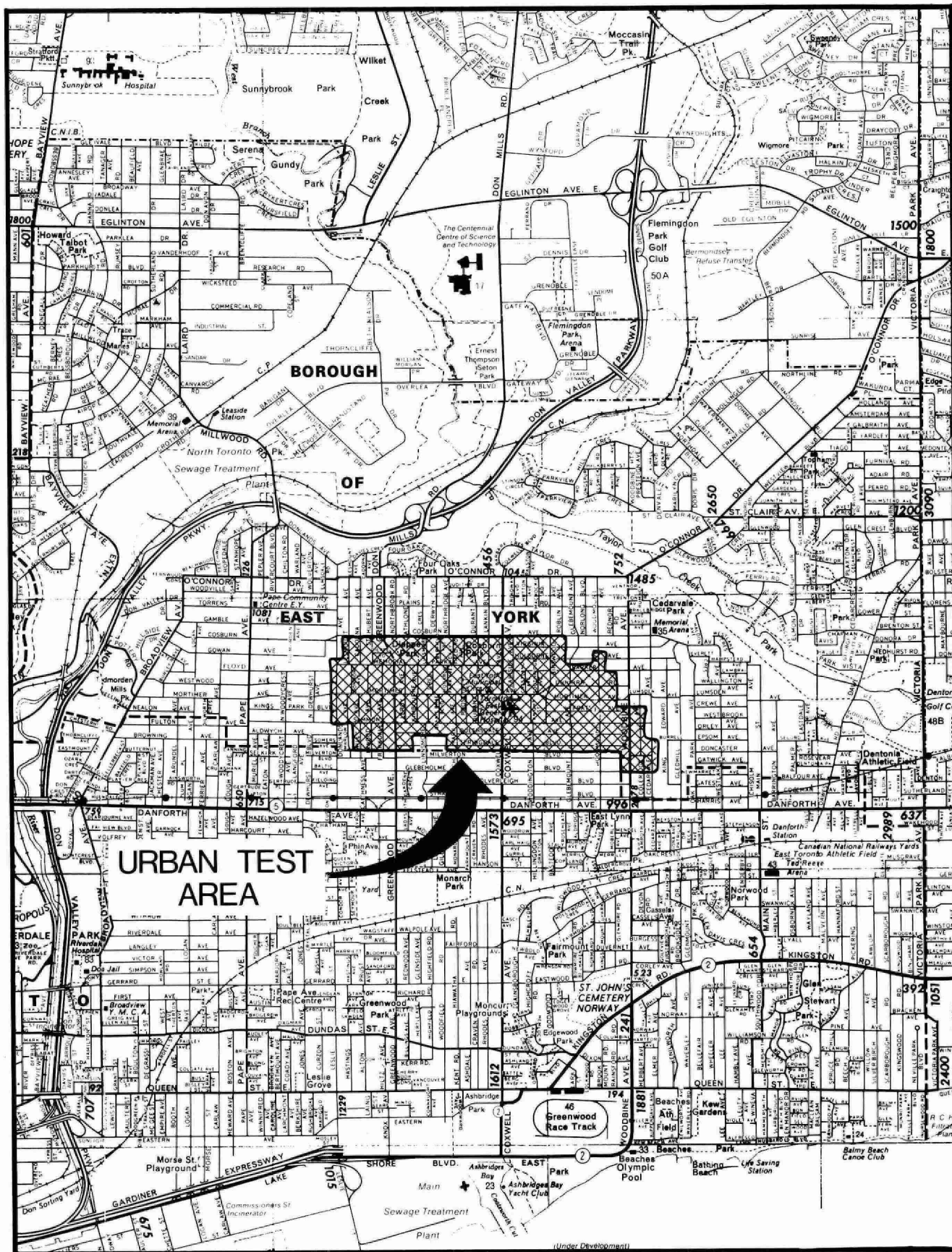


FIGURE 1. URBAN TEST AREA

TABLE 1. APPROXIMATE DISTRIBUTION OF EXISTING LAND USE
WITHIN URBAN TEST AREA

Land Use	Percentage of Total Area
1) RESIDENTIAL	
Single-family residential units	88.2
Multi-family residential units	0.9
2) INSTITUTIONAL	
Toronto East General Hospital	2.3
R.H. McGregor Public School	1.4
Holy Cross Separate School	0.7
St. Aloysius Separate School	0.3
Miscellaneous including Borough Hall and East York General Library	1.0
3) PARKS AND OPEN SPACES	
Dieppe Park	2.0
Cosburn Park	0.8
Memorial Gardens	1.4
4) COMMERCIAL	1.0
5) INDUSTRIAL	Nil

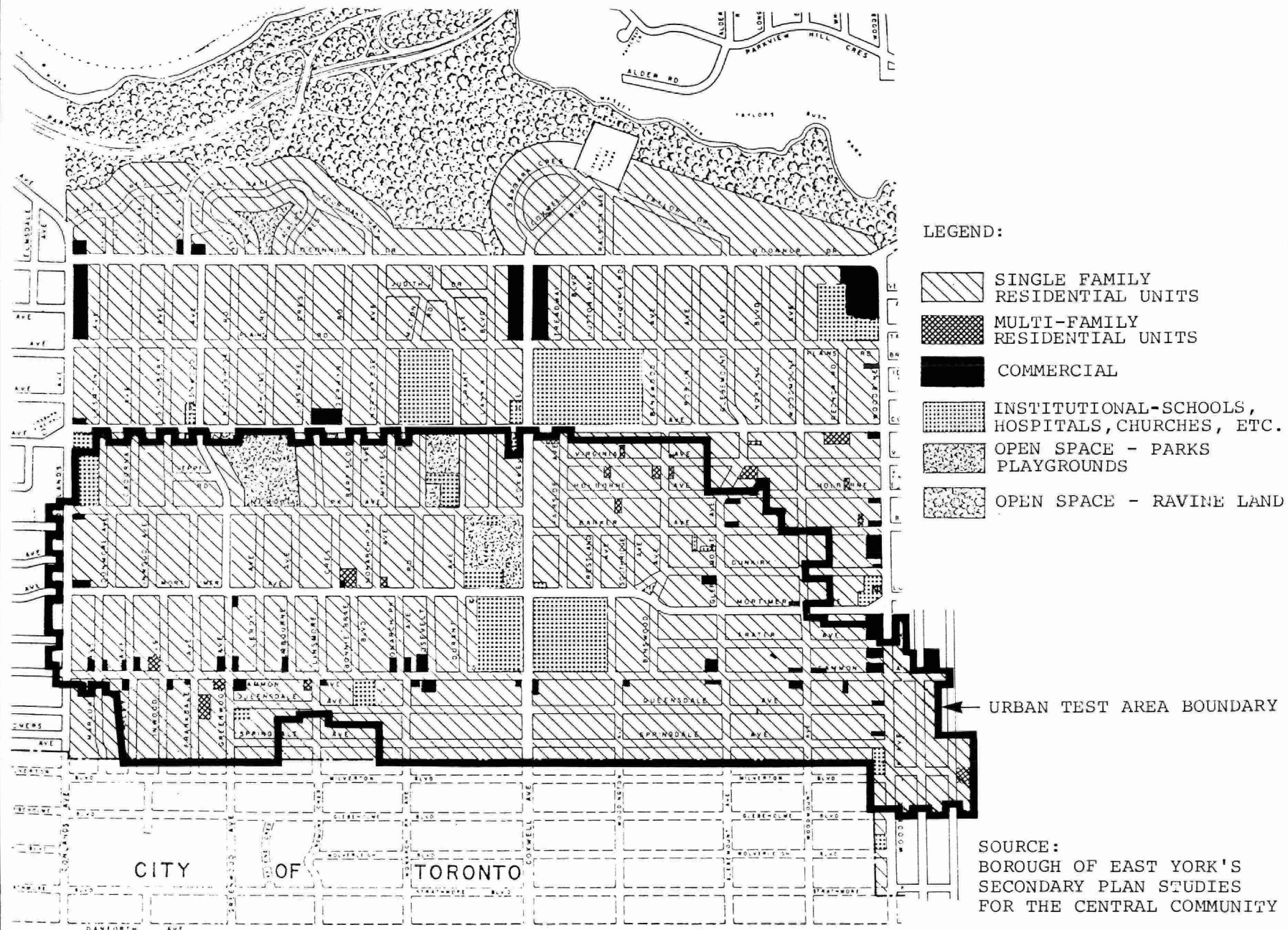


FIGURE 2. EXISTING LAND USE

population whose children grew up and left home. Since 1966 there appears to have been a gradual increase in population (average annual increase of about 0.26%) because of changes in the ethnic composition of the population and new young families buying the houses of older people. A figure for the current population within the study area is not readily available but is estimated to be in the region of 14 600.

In 1966 the average household size within the study area ranged from 2.8 to 3.9 persons per household, with the average being in the region of 3.3. In the same year the gross residential density of population varied from 25 to 75 persons per acre with a spatial distribution as shown on Figure 3.

2.2 Hydrologic Characteristics

The area of impervious elements within the urban catchment area was established from aerial photographs (an example is presented in Figure 4 to give an indication of the ground cover and distribution of the impervious surfaces) and from topographical maps. The area of impervious elements is 187 acres, which corresponds to 49% of the total surface area (383 acres) of the catchment. These impervious elements comprise roads, sidewalks and driveways (52%); roofs of houses connected to sewers (38%); roofs of sheds not connected to sewers (4%); and miscellaneous elements (6%).

2.3 Drainage System

All wastewater and storm or surface water within the study area drains to a manhole at the junction of Frankdale Avenue and Memorial Park Avenue. The more important elements which play a part in the conveyance of these waters to the point of discharge are roof drainage connections, road gutters, catch basins and sewer pipes. It should be noted that parts of the study area were developed in the early 1920's, and as a consequence a substantial amount of maintenance work would have been carried out on these elements. This may imply that details of some of these elements differ from the standard descriptions presented in this section.

2.3.1 Roof and foundation drainage

All the houses within the study area have, or are supposed to have, roof drainage connections to the combined sewers. Since the urban

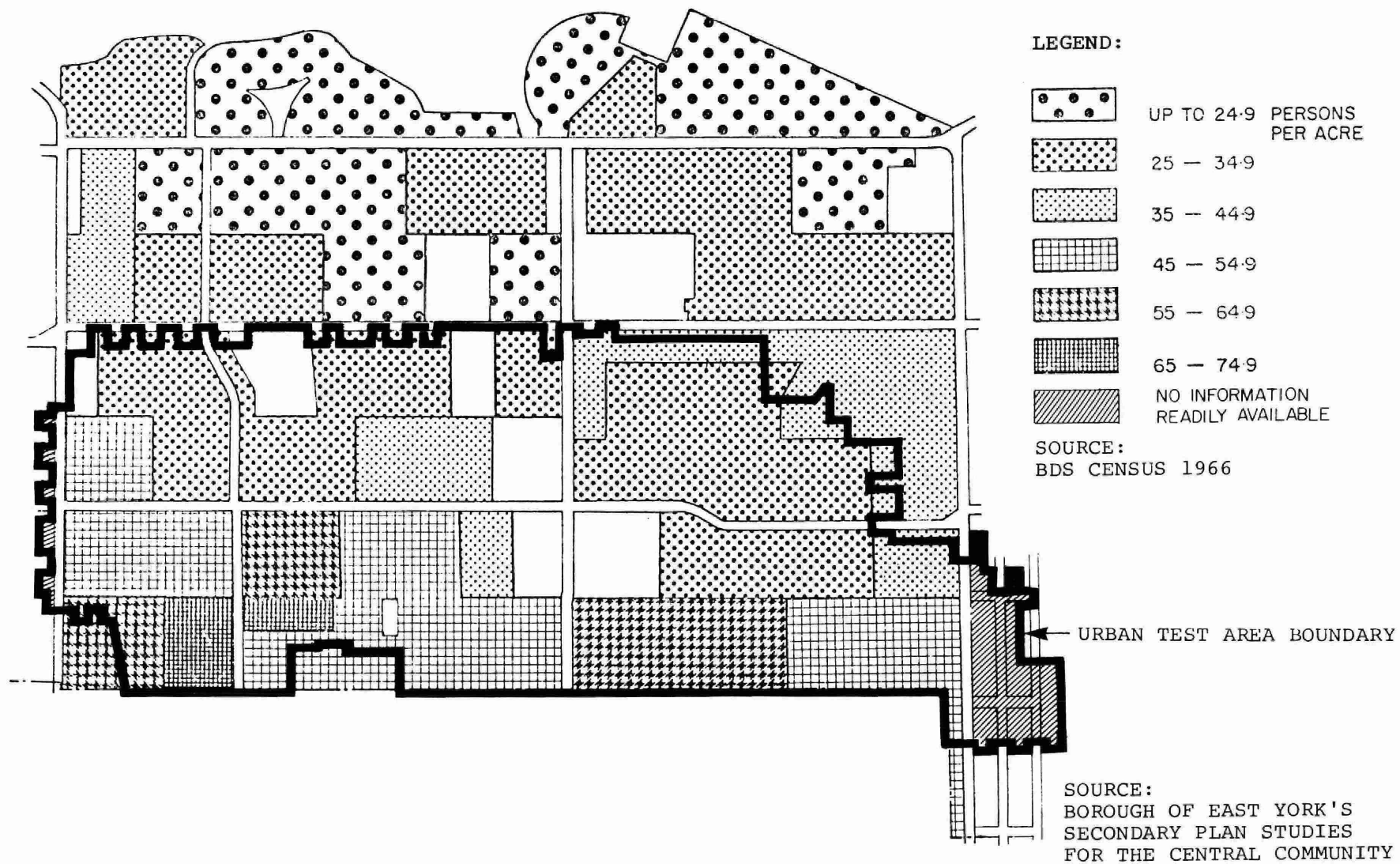


FIGURE 3. GROSS RESIDENTIAL DENSITY OF POPULATION

catchment area is only served by combined sewers, all foundation drains are connected into them.

2.3.2 Road gutters

The standard road cross sections used in the Borough of East York, which show the details of the road gutters, are presented in Figure 5. The cross section most commonly used within the study area is believed to be the one bounded by a heavy line on Figure 5. However, the majority of roads have been resurfaced by the application of a very thin layer of "slurry seal"; an asphaltic emulsion containing a graded stone screening and cement. Unfortunately, there is no information available on the camber of the roads but it is believed that in the days when the roads were constructed all cambers were introduced by eye.

2.3.3 Catch basins

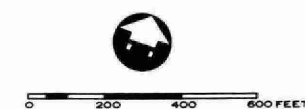
A survey was carried out which revealed that there are 481 catch basins; a density of 1.26 per acre. The details of the catch basins are presented on Figure 6, from which the volume of the sump was calculated to be 13 cubic feet.

2.3.4 Sewer pipes

A plan of the sewer system showing the diameter, length and slope of the sewer pipes is presented in Figure 7. There is no specific information readily available on the material with which the sewer pipes are made. According to the Director of Engineering for the Borough of East York, however, it would be reasonable to assume that pipes of up to 24 inches in diameter are glazed vitrified clay and that the remaining are concrete, except for the 60-inch and 66-inch sewers down Greenwood Avenue and Frankdale Avenue which can be assumed to be of brick.

2.4 Municipal Practices

Certain municipal practices within the study area play an important part in the calibration and verification of the Storm Water Management Model in that they can, and will, affect both the quality and quantity of storm and snow melt runoff. The more important ones, street cleaning, sewer cleaning, and snow and ice control, are described in this section.



LEGEND
 - - - - - BOUNDARY OF URBAN TEST AREA

FIGURE 4. AERIAL PHOTO

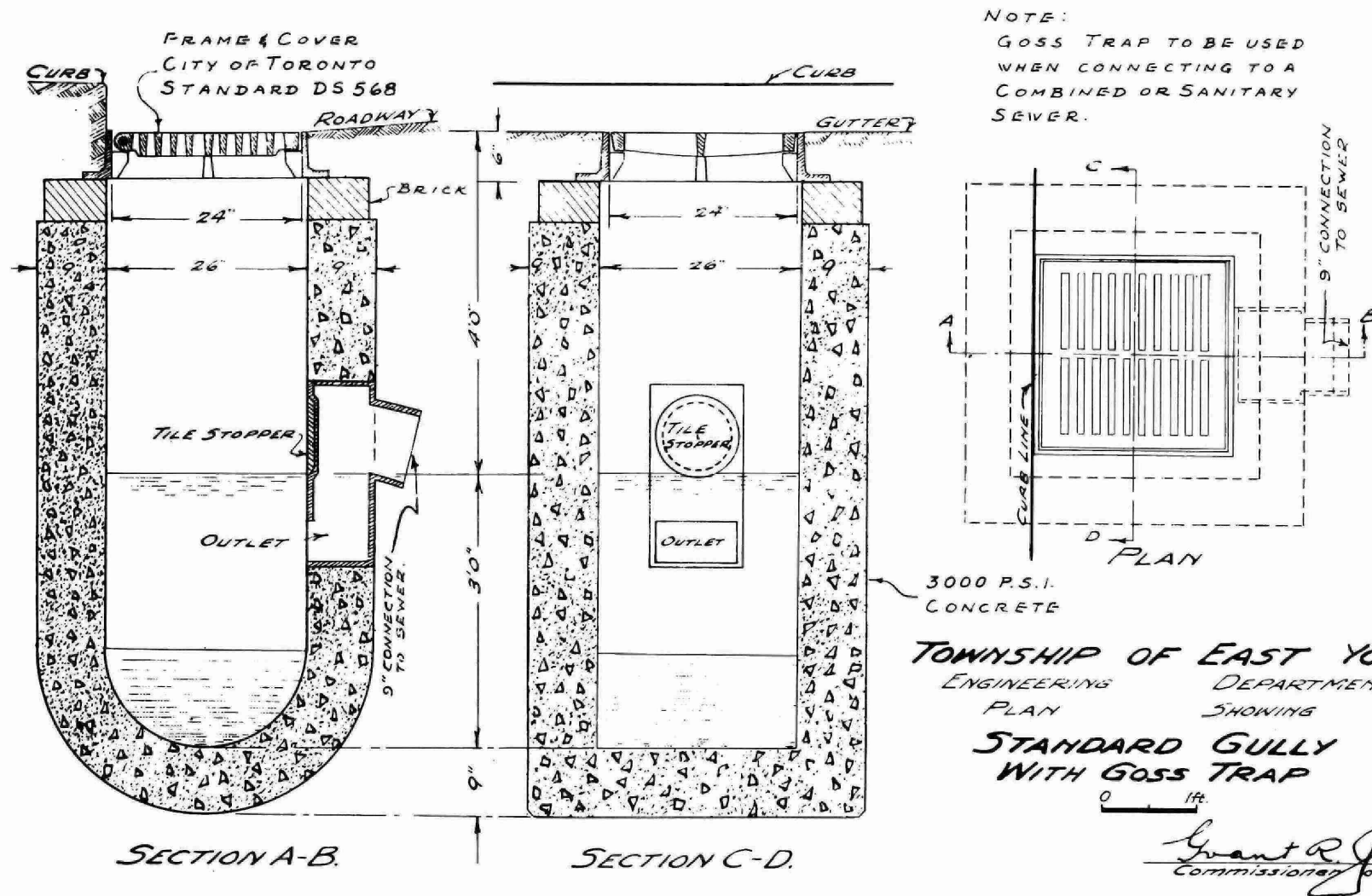


FIGURE 6. CATCH BASIN DETAILS

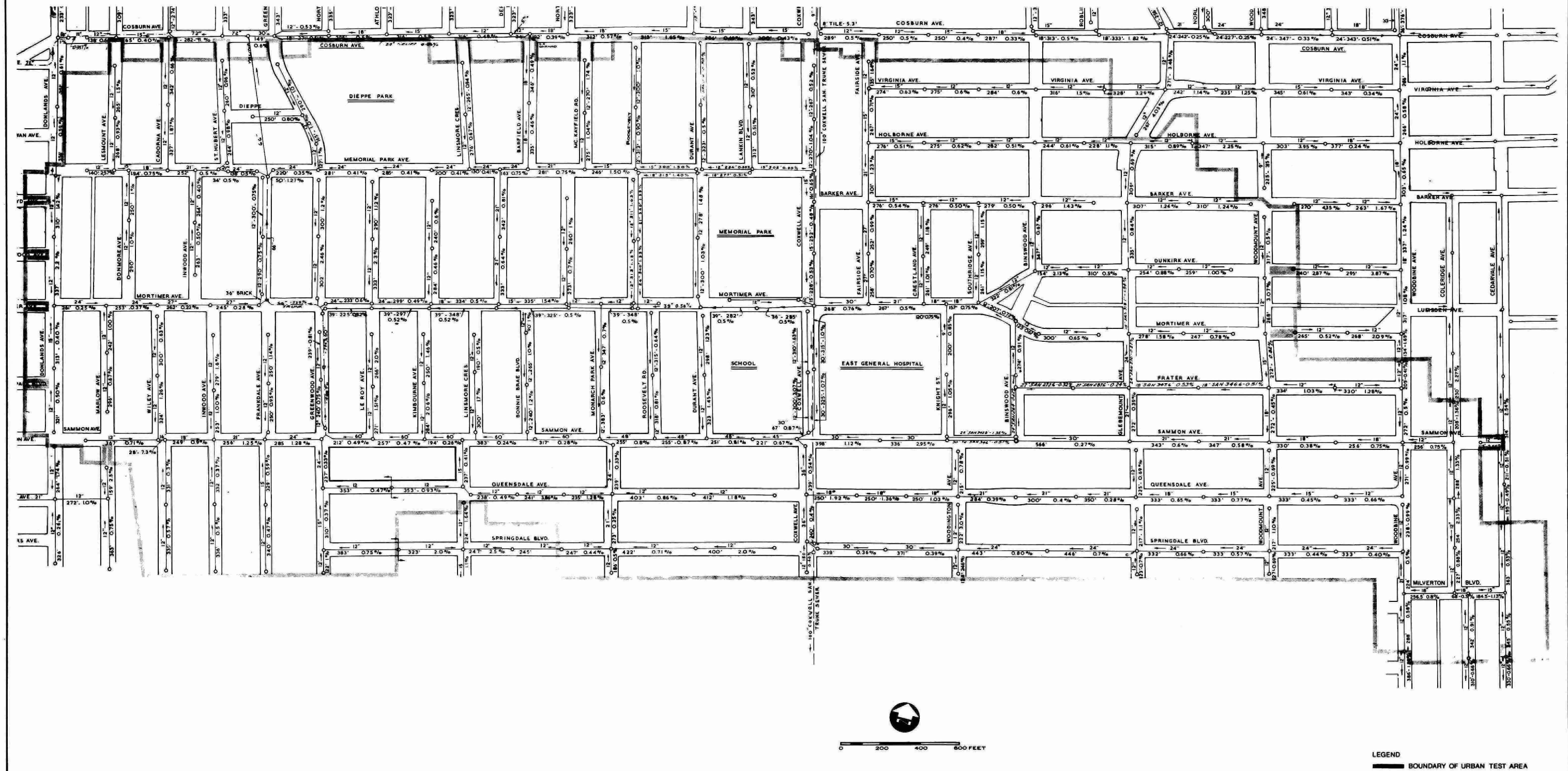


FIGURE 7. 'AS BUILT' SEWER PLAN

2.4.1 Street cleaning

During the period when there is no snow or ice present in the road gutters (usually April to November) the roads are generally swept once a week by a pickup sweeper. On rainy days when mechanized road sweeping is not practical, work crews normally clean the road gutters in the immediate vicinity of the catch basins. The actual dates of street cleaning within the urban catchment area for the years 1976 and 1977 are presented in Tables 2 and 3, respectively.

2.4.2 Sewer cleaning

The municipality does not have a regular program for cleaning sewers. Their first priority is to deal with the day-to-day sewer problems which may occur. Their second priority is to attempt regular maintenance of the sewers in known trouble spots, a few of which are within the study area. As a third priority, trouble-free sewers up to 21-inch diameter are cleaned. Consequently, specific trouble-free sections of the sewer system are cleaned less frequently than once a year.

The catch basins, however, are generally cleaned annually, at a rate of approximately 55 to 60 per day, by means of a vacuum hose. The majority of those within the catchment area were cleaned between July 15 and July 28 in 1976, and September 13 and September 23 in 1977. The total weight of debris removed in 1976 was approximately 92 000 pounds.

2.4.3 Snow and ice control

Adverse snow and ice conditions are dealt with by a combination of salt and sand spreading, road and sidewalk ploughing and snow removal.

The de-icing material used for the roads is rock salt which is applied by means of a highway salt spreader of six tons capacity. The rate at which the salt is spread depends upon the weather conditions. Very occasionally a proportion of sand is mixed with the rock salt. The use of sand as an anti-skid material, however, is generally restricted to sand boxes situated at known trouble spots from which motorists help themselves, and to pedestrian areas such as bus stops and crosswalks.

Salting and sanding is commenced when any or all of the following occur:

TABLE 2. STREET CLEANING WITHIN STUDY AREA DURING 1976
(Number of passes is one except where noted)

Date	Area Swept	Approx. quantity of litter and debris picked up and removed
31 March	Area east of Greenwood	56 cubic yards*
1 April	Area west of Greenwood	5 cubic yards*
6 April	Area east of Greenwood	24 cubic yards
14 April	Area east of Greenwood	5 cubic yards
20 April	Whole area	5 cubic yards
27 April	Whole area	12 cubic yards
4 May	Whole area	12 cubic yards
12 May	Whole area	12 cubic yards
18 May	Whole area	9 cubic yards
25 May	Whole area	9 cubic yards
2 June	Whole area	6 cubic yards
8 June	Whole area	21 cubic yards
18 June	Whole area	5 cubic yards
21 June	Whole area	9 cubic yards
6 July	Area west of Coxwell	6 cubic yards
7 July	Area east of Coxwell	6 cubic yards
20 July	Area east of Greenwood	12 cubic yards
22 July	Area west of Greenwood	3 cubic yards
27 July	Whole area	6 cubic yards
3 August	Whole area	6 cubic yards
10 August	Whole area	6 cubic yards
17 August	Whole area	5 cubic yards
24 August	Whole area	6 cubic yards
14 September	Whole area	9 cubic yards
21 September	Whole area	9 cubic yards
28 September	Whole area	6 cubic yards
5 October	Whole area	12 cubic yards
12 October	Whole area	12 cubic yards
19 October	Area east of Greenwood	18 cubic yards
26 October	Whole area	36 cubic yards
2 November	Whole area	60 cubic yards
4 November	Whole area	60 cubic yards
15 November	Area west of Coxwell	36 cubic yards

* Two passes or more.

TABLE 3. STREET CLEANING WITHIN STUDY AREA DURING 1977
(Number of passes is one except where noted)

Date	Area Swept	Approx. quantity of litter and debris picked up and removed
5 April	Area east of Coxwell	15 cubic yards
7 April	Area west of Coxwell	24 cubic yards
20 April	Area east of Coxwell	12 cubic yards
21 April	Area west of Coxwell	8 cubic yards
28 April	Area east of Greenwood	18 cubic yards
29 April	Area west of Greenwood	3 cubic yards
11 May	Whole area	12 cubic yards
18 May	Area east of Coxwell	6 cubic yards
19 May	Area west of Coxwell	6 cubic yards
20 May	Area east of Coxwell	5 cubic yards
24 May	Area west of Coxwell	6 cubic yards
27 May	Area east of Greenwood	6 cubic yards
30 May	Area west of Greenwood	3 cubic yards
1 June	Area east of Coxwell	6 cubic yards
3 June	Area west of Coxwell	3 cubic yards
10 June	Area east of Greenwood	9 cubic yards
13 June	Area west of Greenwood	3 cubic yards
21 June	Whole area	9 cubic yards
28 June	Whole area	6 cubic yards
5 July	Whole area	6 cubic yards
12 July	Area east of Coxwell	3 cubic yards
13 July	Area west of Coxwell	3 cubic yards
25 July	Whole area	6 cubic yards
4 August	Area east of Coxwell	9 cubic yards
5 August	Area west of Coxwell	3 cubic yards
19 August	Area east of Coxwell	3 cubic yards
23 August	Area west of Coxwell	6 cubic yards
30 August	Area east of Greenwood	3 cubic yards
31 August	Area west of Greenwood	3 cubic yards
7 September	Area east of Greenwood	6 cubic yards
8 September	Area west of Greenwood	6 cubic yards
13 September	Area east of Coxwell	3 cubic yards
15 September	Area west of Coxwell	3 cubic yards
20 September	Area east of Coxwell	6 cubic yards
21 September	Area west of Coxwell	9 cubic yards
27 September	Whole area	15 cubic yards
5 October	Area west of Coxwell	15 cubic yards
11 October	Area east of Greenwood	9 cubic yards
12 October	Area west of Greenwood	3 cubic yards

- i) complaints of slippery streets,
- ii) sleet or ice storms,
- iii) snowfalls,
- iv) freezing weather after a thaw or rainfall, and
- v) after snow removal.

Details of road salting within the study area during the 1975/1976 winter are presented in Table 4.

Complete-coverage road-ploughing generally takes place after a snow accumulation of about 3 inches or more. Sidewalk ploughing generally takes place after a snowfall of about $1\frac{1}{2}$ inches. The snow from both the road and sidewalk is ploughed into the road gutter. For the 1975/1976 winter, the dates of road and sidewalk ploughing within the study area are presented in Table 5.

Snow is only removed if the accumulation of snow in the windrow along the edge of the road becomes unmanageable and if there is no likelihood of thawing weather conditions. Details of snow removal for the 1975/1976 winter are presented in Table 6.

TABLE 4. SALTING OF ROADS WITHIN STUDY AREA
DURING THE 1975/1976 WINTER

Approximate Tonnage of Salt Spread		Approximate Tonnage of Salt Spread	
Date		Date	
November	Nil	19 January	6
2 December	8	20 January	12
3 December	4	21 January	18
4 December	1	22 January	6
9 December	4	23 January	6
10 December	1	24 January	24
16 December	6	25 January	2
17 December	6	26 January	3
18 December	6	27 January	12
19 December	5	28 January	6
20 December	6	29 January	18
21 December	6	30 January	6
23 December	6	31 January	2
24 December	2	1 February	2
25 December	1	2 February	3
26 December	6	3 February	1
2 January	6	5 February	2
3 January	1	6 February	2
5 January	2	22 February	2
6 January	3	1 March	2
7 January	12	2 March	12
8 January	1	3 March	24
9 January	1	4 March	6
11 January	24	12 March	2
12 January	18	16 March	18
13 January	6	17 March	12
14 January	12	18 March	6
15 January	4	19 March	2
16 January	18	22 March	2

TABLE 5. ROAD AND SIDEWALK PLOUGHING WITHIN STUDY AREA
DURING THE 1975/1976 WINTER

All sidewalks were ploughed on:
December 9, 17, 20, 21 and 26.
January 7, 11, 12, 14, 16 and 24.
March 2.

All roads were ploughed on:
December 20, 21, 26.
January 12 and 14.
March 2.

TABLE 6. SNOW REMOVAL FROM WITHIN STUDY AREA DURING
THE 1975/1976 WINTER

Date	Roads
29 December	Mortimer, Knight
30 December	Dunkirk, Barker, Holborne, Virginia, Woodmount, Springdale, Queensdale, Glebemount
31 December	Binswood, Glebemount, Frater, Southridge, Crestland, Woodington, Fairside
5 January	Memorial, Lankin, Durant, Roosevelt, McKayfield, Barfield, Linsmore, Greenwood, Mortimer, Monarch Park, Kimbourne, Leroy, Bonnie Brae, Sammon, Frankdale, Inwood, Wiley, Marlow, Donmore, St. Hubert, Dieppe, Cadorna, Lesmount
6 January	Durant, Linsmore, Sammon, Dunkirk, Barker, Holborne, Virginia, Woodmount, Springdale, Queensdale, Sammon
16 January	Springdale, Queensdale, Woodington, Glebemount, Queensdale, Binswood, Knight, Frater, Fairside
19 January	Southridge, Crestland, Mortimer, Sammon
20 January	Durant, Roosevelt
21 January	Frankdale, Inwood, Wiley, Marlow, Sammon, Mortimer, Durant, Roosevelt, Monarch Park, Bonnie Brae, Linsmore, Kimbourne, Leroy
22 January	Mortimer, Monarch Park, Linsmore, Kimbourne, Leroy, Greenwood, Frankdale, Inwood, Donmore, Memorial Park, McKayfield, Barfield
23 January	Linsmore, Greenwood, St. Hubert, Dieppe Road, Cadorna, Sammon, Donlands
6 February	Mortimer
10 February	Woodmount
11 February	Donlands, Glebemount, Mortimer, Binswood, Holborne, Frater
12 February	Memorial, Leroy

3. INSTRUMENTATION AND DATA ACQUISITION

3.1 Introduction

To generate data for the verification of the Storm Water Management Model (SWMM) a data acquisition system was designed and installed. The aim of the system was to measure precipitation, air temperature, and the quantity and quality of the runoff, so that precipitation hyetographs, air temperature graphs, storm hydrographs, and pollutographs could be produced. A schematic diagram of the data acquisition system is presented in Figure 8.

During the period November 1, 1975, to March 31, 1977 a complete set of monitored data was collected for 31 precipitation events (see Table 7 for a listing); nineteen of these were used in testing SWMM simulations. In the period April 1, 1977 to October 31, 1977 no complete set of monitored data were obtained due to equipment problems; notably a malfunction of the flow measuring system (February 2, 1977 to May 9, 1977), pump blockages in the storm water sampler, submergence and consequent damage to the sample pump due to several large storms in July 1977, and various equipment failures due to wear. With the exception of three intense storms on June 25, June 29, and August 10, 1977, flow hydrographs and rainfall hyetographs without accompanying water quality data have not been summarized in this report. The raw data for producing these are available, however, from the Ontario Ministry of the Environment (Water Modelling Section of the Water Resources Branch).

3.2 Installation and Location of Data Acquisition System

The majority of the work involved in installing the data acquisition system was carried out by an electrical and mechanical contractor. The major components making up the system were located as follows:

- i) In a 66" diameter sewer, approximately 100' downstream of the manhole at the junction of Memorial Park Avenue and Frankdale Avenue
 - weir plates
 - discharge point of compressed air

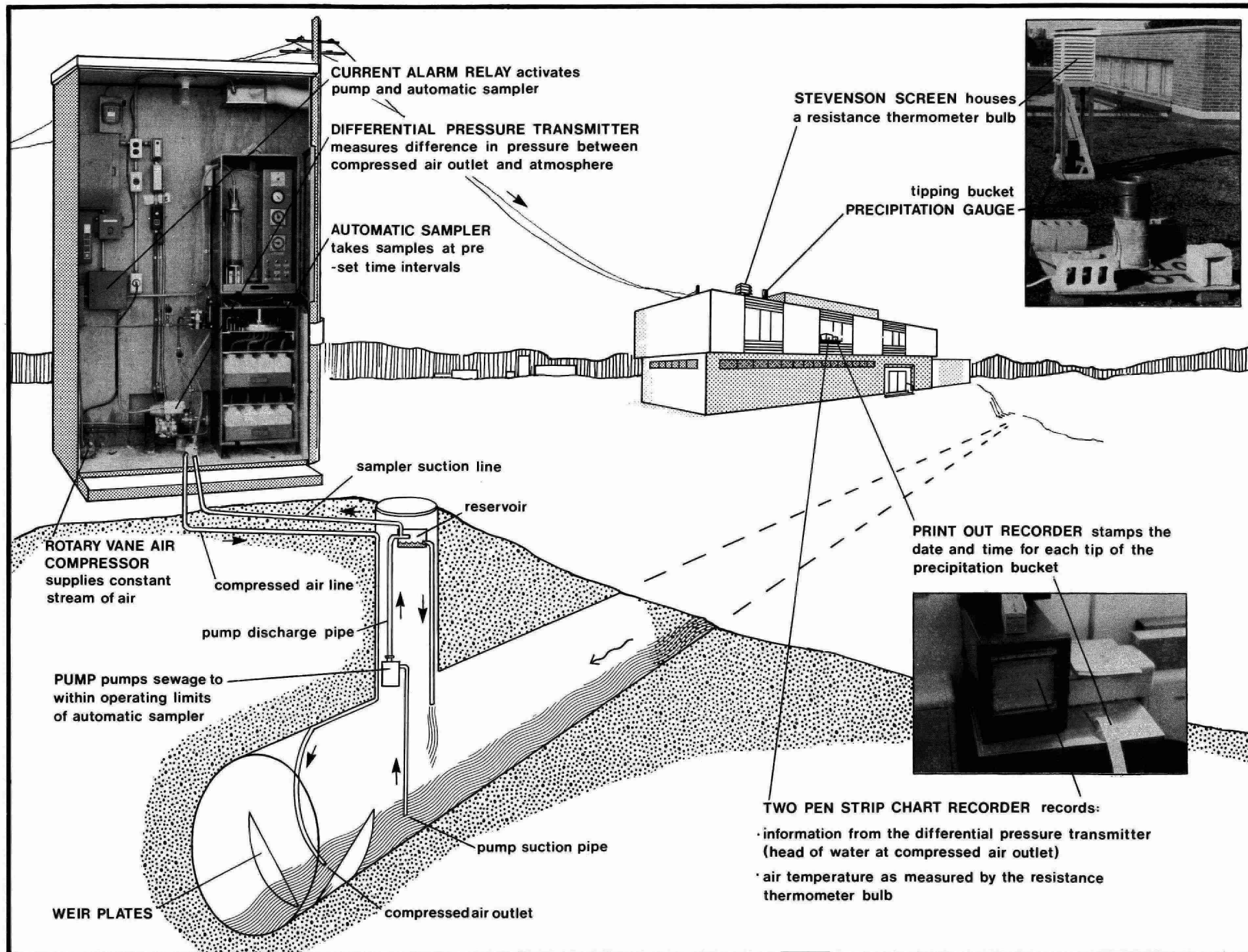


FIGURE 8. SCHEMATIC OF DATA ACQUISITION SYSTEM

TABLE 7. PRECIPITATION-RUNOFF EVENTS MONITORED FOR QUANTITY AND QUALITY

Date of Event	Duration (hours)	Total Precipitation (inches)	Presentation of Hydrograph, Hyetograph and Pollutographs
06/12/75	4.82	**	Figure XIX
09/12/75	18.35	**	Figure XX
30/12/75	2.18	**	Figure XXI
26/01/76	19.12	**	Figure XXII
05/03/76	4.80	**	Figure XXIII
27/03/76*	1.42	0.16	Figure II
31/03/76*	11.33	0.91	Figure III
22/04/76*	0.52	0.08	Figure IV
24/04/76* }	5.37	0.31	Figure V
25/04/76*			
25/04/76	2.50	**	Figure XXIV
06/05/76	4.40	0.25	Figure XXV
06/05/76	5.28	0.28	Figure XXVI
11/05/76*	0.62	0.15	Figure VI
01/06/76*	0.75	0.10	Figure VII
28/06/76*	0.38	0.06	Figure VIII
30/06/76*	2.38	0.25	Figure IX
30/06/76*	1.38	0.10	Figure IX
01/07/76*	0.90	0.16	Figure X
01/07/76*	0.15	0.22	Figure XI
02/07/76*	1.02	0.12	Figure XII
07/07/76*	1.15	0.23	Figure I
11/07/76*	1.12	0.12	Figure XIII
16/07/76	0.43	0.07	Figure XXVII
20/07/76* }	3.53	0.53	Figure XIV
20/07/76*			
29/07/76*	3.38	0.46	Figure XV
31/07/76*	2.68	0.38	Figure XVI
13/08/76*	0.17	0.22	Figure XVII
28/08/76	1.67	0.97	Figure XXVIII
01/09/76*	1.17	0.21	Figure XVIII

* Precipitation-runoff events selected for calibration and verification.

**Rain and/or melting snow.

- ii) In a manhole at the junction of Memorial Park Avenue and Frankdale Avenue
 - sewage lift pump
- iii) In an insulated housing situated on the southeast Memorial Park Avenue and Frankdale Avenue
 - rotary vane air compressor
 - differential pressure transmitter
 - alarm relay
 - automatic sampler
- iv) On the roof of the East York Borough Hall
 - precipitation gauge
 - Stevenson screen housing the resistance thermometer bulb
- v) In an office of Borough Hall*
 - two-pen strip chart recorder, recording head of water and temperature
 - print-out recorder, recording precipitation

3.3 General Weather Data

Temperature and precipitation were monitored by instruments located on the roof of the East York Borough Hall and recorded in an office of the same building. Intensity (i.e., amount of rain falling per unit time), duration, and total amount of precipitation for a storm event are the primary input to simulations using the SWMM.

3.3.1 Temperature measurement

A Bristol resistance thermometer bulb, which provides an electrical signal for recording purposes, was selected for measuring the air temperature. This resistance thermometer was housed in a Stevenson screen which protected the instrument from sun and wind while permitting free ventilation.

* Time synchronization of the events monitored by the recorders (crucial to the success of the project) was a simple task as the instruments were located adjacent to one another. The strip chart was graduated in the time-of-day, while the print-out recorder printed the actual date and time to the nearest minute. The time-point when the runoff sampler was activated (at a flow rate of 15 cfs) could be read from the strip chart; sampling then continued at 6 minutes 40 second intervals (see section 3.4.2) so the time at which each sample was taken could easily be inferred from the initial time-point.

The output from the resistance thermometer was fed to one channel of a two-pen strip chart recorder (the other channel recorded runoff flow - see section 3.4.1). The recorder was a Bristol Dynamaster Model No. 2PH-PJ-760-281 BX and had a 7-inch strip chart calibrated in time-of-day. Two chart speeds were available, 6" and 3" per hour, and the slower speed (3"/h) was used throughout the study.

3.3.2 Precipitation measurement

Precipitation was measured by a Meteorological Service of Canada (MSC) tipping bucket rain gauge. This gauge consists of two balanced buckets, which tip back and forth as they are filled in turn by rainfall directed to them by a collecting funnel. Every time the bucket tips a relay contact is operated which provides an electrical signal to a recording device. The device used was a Landis and Gyr Sodeco Model PL105 print-out recorder that prints the actual date and time, to the nearest minute, every time the rain gauge bucket tips indicating 0.01" of rainfall. As the recorder can cope with one impulse every second it is capable of measuring a rainfall intensity of up to 36" per hour.

3.3.3 Data obtained

Daily maximum and minimum temperatures, and total rainfall and the maximum rainfall occurring in 1, 5 and 10 minutes for each day are presented in monthly summary tables in Appendix A. The precipitation recorded throughout the winter months cannot be considered very reliable as it can represent one or a combination of the following:

- i) the melting of old accumulated snow in the collecting funnel,
- ii) the melting of freshly fallen snow, and
- iii) rain.

As a consequence, all recorded data in this category have been included in the column headed "rain and/or melting snow" in the monthly summary tables. In addition, rainfall intensity (recorded as timed impulses on the print-out recorder) for storms with a complete set of monitored data (i.e., those listed in Table 7) and for those which occurred on June 25, June 29, and August 10, 1977, are presented in Appendix B. The rainfall

hyetographs shown on the hydrographs and pollutographs presented in this report (Figures I to XXXI in Appendix C) were derived from this information.

During the 1975/1976 winter, snow surveys were carried out in order to establish the snow depth and its water equivalent whenever it was anticipated that there would be a significant snow melt event. Such snow surveys were carried out on December 23, 1975, and January 16, January 26, February 10, March 5 and March 19, 1976. A summary of the reports is presented in Table 8. No snow surveys were carried out during the 1976/1977 winter.

3.4 Measurements of the Runoff

The effluent from the sewer system in the study area discharges into a 66" diameter sewer at the junction of Memorial Park Avenue and Frankdale Avenue. Access to the sewer is through a manhole and 22" diameter opening. Flow of the runoff in the sewer was determined through measurement of the head-of-water over a "partial trapezoidal" weir, and sewage water for sample collection and subsequent quality analysis was extracted using a pump situated in the manhole. Measuring instrumentation and an automatic sampler were housed in an above-ground weather-proof housing; the signal from the head-of-water measurement was conducted via a land line to the strip chart recorder located in the Borough Hall.

3.4.1 Flow measurement

The manhole into which the test area drains has two drop-shaft inlets which create a hydraulic disturbance. This feature makes the manhole an unsuitable place for flow measurements; consequently, the flow measuring device was installed in the 66" sewer 100 feet downstream of the disturbance. An inspection of the dry weather flow at this point showed that it was free from hydraulic interference from both downstream conditions and upstream disturbances.

Because access to the 66" sewer was limited (a 22" opening) it was anticipated that installation difficulties would be encountered if flumes were used. A "partial trapezoidal" weir was selected, therefore, as the flow measuring device. The weir plates, details of which are shown in Figure 9, were manufactured from $\frac{1}{2}$ " steel plate and then hot-dipped

TABLE 8. SUMMARY OF SNOW SURVEY REPORTS

Date	Number of Sampling Stations	Mean Snow Depth (inches)	Mean Water Equivalent (inches)	Mean Density	Remarks
23/12/75	17	6.9	0.8	0.12	Survey carried out in the morning.
16/01/76	13	14.7	3.0	0.20	Survey started 09:30, ended 11:30. Ice layer about 6" from surface. Entire area snow covered. Snow wet and melting.
26/01/76	9	13.1	3.6	0.27	Survey started 10:15, ended 11:15. Thin ice layer. Road surface almost bare. Rooftops 75% bare. Sidewalks very slushy with up to 6" of water in some areas. Snow melting fast.
10/02/76	11	11.8	2.9	0.24	Survey started 09:35, ended 10:30. No ice layers. No snow on sidewalks and rooftops.
05/03/76	11	4.9	2.1	0.43	Survey started 13:00, ended 14:15. No ice layers. Rain in morning. Snow on sidewalks and rooftops. Snow very wet and melting fast.
19/03/76	10	3.7	1.1	0.29	Survey started 09:20, ended 10:30. Ice layer about 3" from surface. No snow on sidewalks and rooftops. Snow wet and melting.

NOTE:

1. Weir plates are to be manufactured from $\frac{1}{2}$ " thick steel.
2. After manufacture, the weir plates are to be hot dipped galvanized.

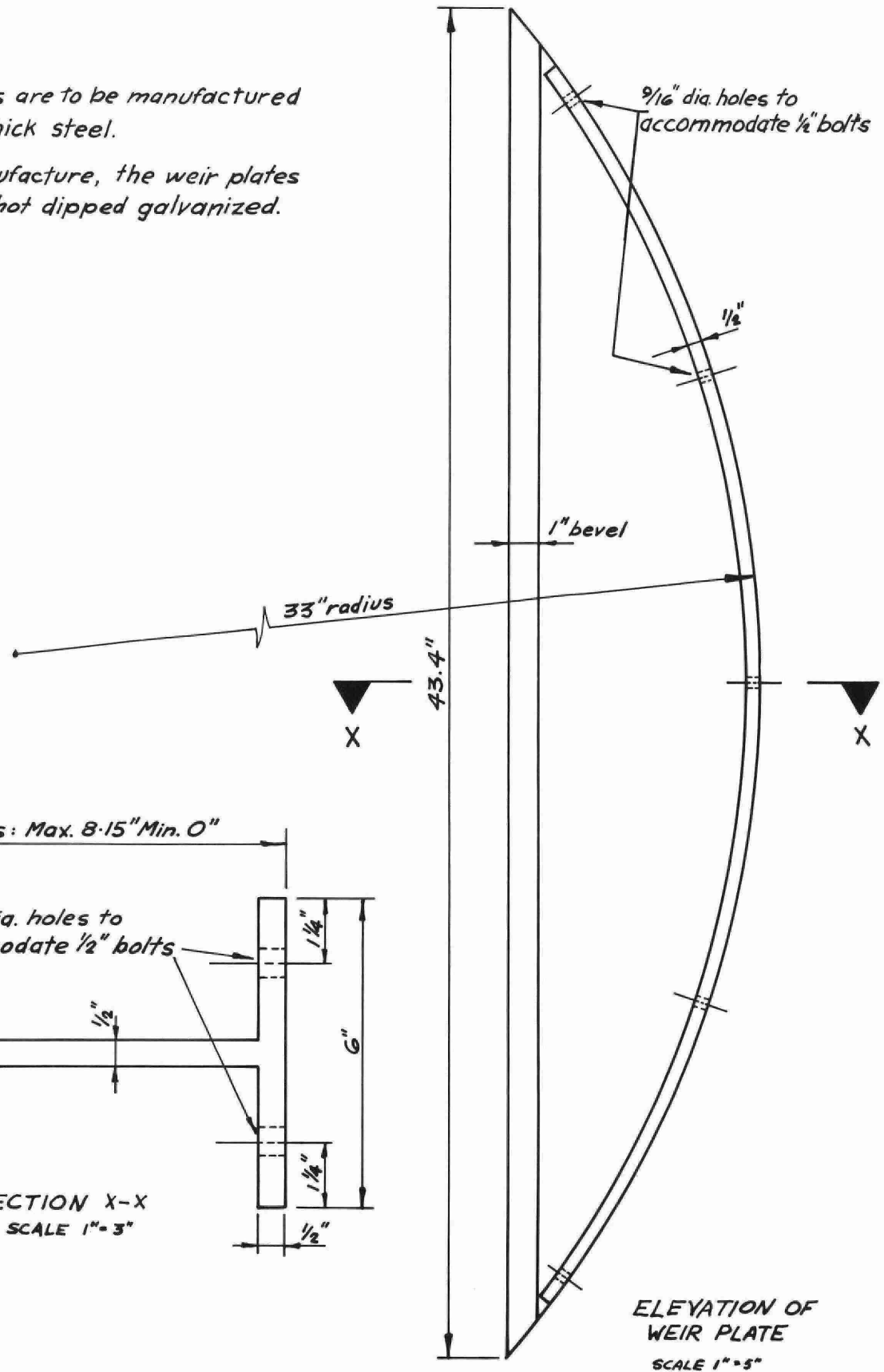
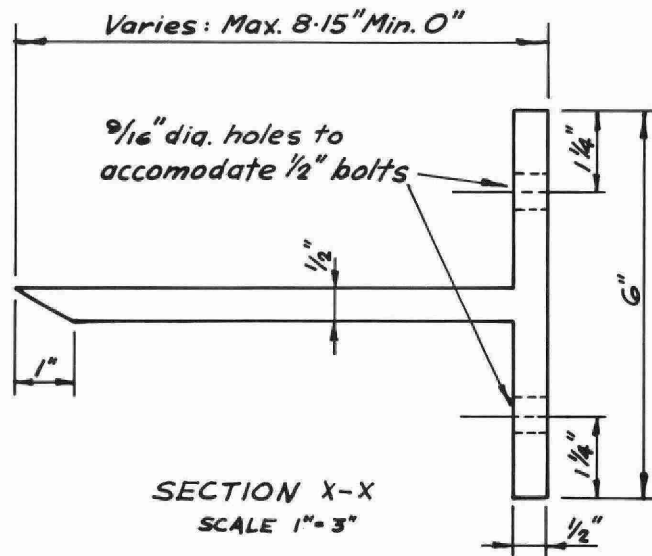


FIGURE 9. DETAILS OF WEIR PLATES

galvanized in order to prevent corrosion. The plates occupied approximately 13.8% of the total cross-sectional area of the 66" diameter outlet pipe and were positioned as shown in Figure 10. The head-of-water generated by flow over the weir was calibrated with respect to total flow volume by scale modelling in the hydraulic laboratory of the Canada Centre for Inland Waters; the resulting rating curve is presented in Figure 11..

In order to measure the head-of-water immediately upstream of the weir a "bubbler type" system was chosen (see Figure 8 for a schematic of the system). Air, supplied by a Rotary Vane Air Compressor Model No. 1531, Gast Manufacturing Company, was bubbled from a point located 6 ft upstream of the weir plates. The air flow was regulated by a Rotameter Model No. 1083135N fitted with a constant differential pressure regulator Model No. 53RB2110. A differential pressure transmitter (Bristol Metatron 2000 Differential Pressure Transmitter) measured the difference in pressure between the atmosphere and the compressed air outlet in the sewer. This pressure difference corresponded to the head-of-water flowing over the weir. The signal from the pressure transmitter was recorded by one channel of the two-pen strip chart recorder described in Section 3.3.1.

3.4.2 Water quality measurements

The Storm Water Management Model (SWMM) includes subroutines for the prediction of the behaviour of generalised parameters of water quality, two of which are biological oxygen demand (BOD) and suspended solids (SS), during a storm event. In addition to these two, opportunity was taken to measure a number of other water quality parameters: chemical oxygen demand (COD), dissolved solids, various forms of nitrogen and phosphorous, and potential toxic pollutants (Pb, phenols, Cl^- , SO_4^{2-}). Monitoring of these parameters required taking samples of the runoff sewage at regular intervals during a storm event.

The automatic sampler used in this study was a non-refrigerated "Sirco Series B/ST-VS", with the capability of obtaining up to 24 samples retained in 1000 ml jars, which was integrated with an explosion proof sampling pump (FA22 C9Q Moyno pump with a class 1, group D, 1750 rpm, $\frac{1}{2}$ hp 110-volt motor) located in the manhole (see Figure 8). Sampling was commenced whenever the flow of water over the weir reached 15 cfs, and

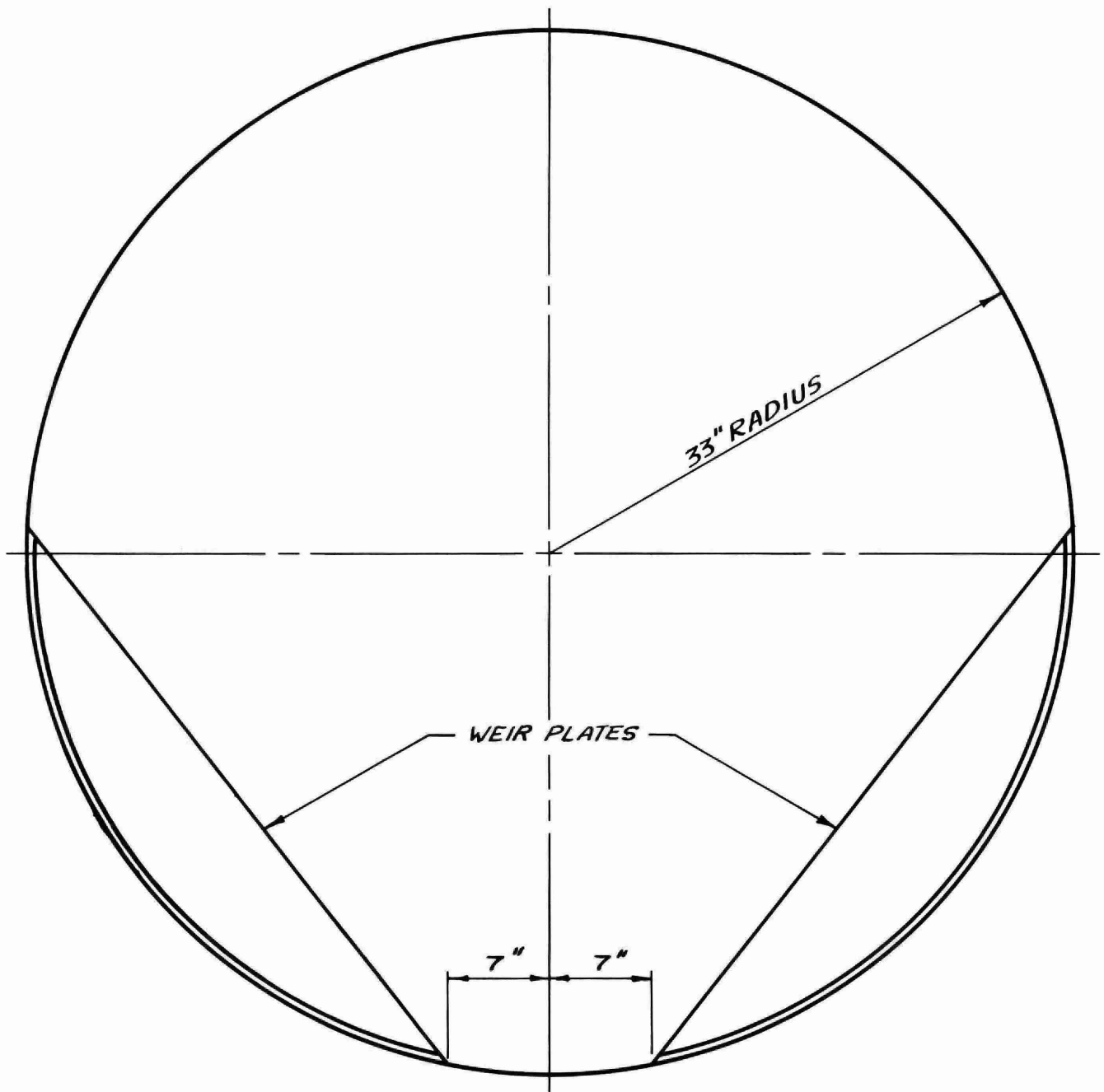


FIGURE 10. POSITION OF WEIR PLATES

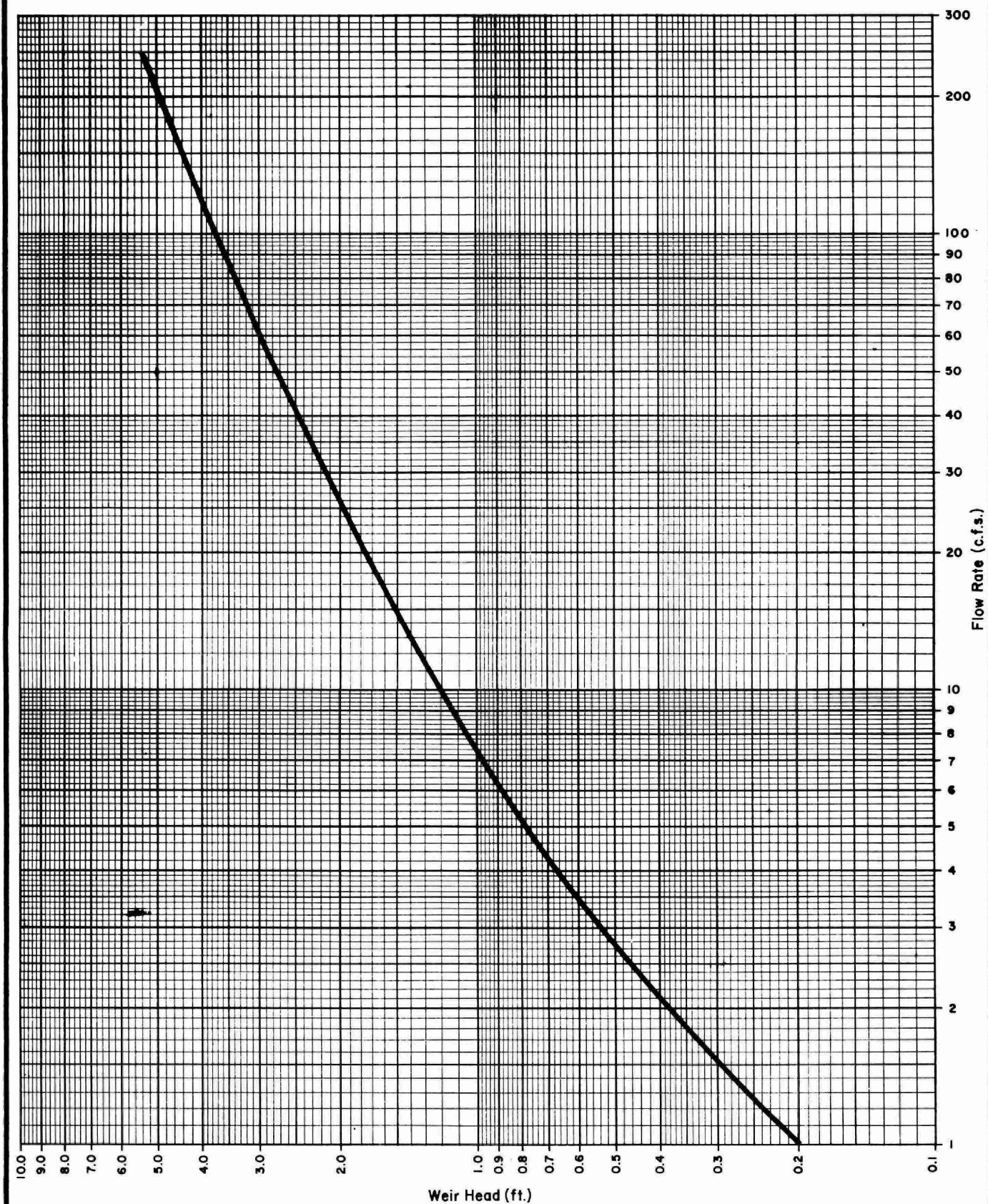


FIGURE 11. WEIR RATING CURVES

was continued at 6-minute 40-second intervals until the flow had dropped to 8.6 cfs or until 24 samples had been collected. This sampling operation was controlled by a current alarm relay (17GM current alarm model TA 4034-1C) which was set to operate when the signal from the height-of-water differential pressure transmitter corresponded to a flow rate of 15 cfs, and to deactivate when the signal fell to below 8.6 cfs.

The collected samples were taken to the Ontario Ministry of the Environment laboratories, in most cases within a few hours of sampling, where they were analysed by the methods described in "Outline of Laboratory Methods", published by the Ontario Ministry of the Environment, Laboratory Services Branch, 1975.

3.4.3 Data obtained

Water flow in the outlet sewer was monitored continuously. The hydrographs for the precipitation runoff and/or snowmelt events with a complete set of monitored data (listed in Table 7) and for those which occurred on June 25, June 29 and August 10, 1977, are presented in Appendix C (Figures Ia to XXVIIIa, XXIX, XXX, and XXXI). The flow measurements were also used to derive daily and hourly average dry weather flow variations between May and November, the results of which are presented in Figure 12 and in Table 9. No attempt was made to analyse the dry weather flow variations between November and May since it was assumed that there would be long continuous periods with a flow component due to snowmelt. The recorded data, which shows a higher than normal dry weather flow during the winter months, supports this assumption.

The results of the water quality measurements which can be reliably related to flow measurements are presented in Appendix D. In addition, pollutographs of BOD and suspended solids have been produced for those storm events with a complete set of monitored data (listed in Table 7), and are presented in Figures I to XXVIII in Appendix C. In modelling the quality of combined sewer flows, the daily and hourly variations of the dry weather pollutants to be modelled are required as input parameters. For this reason a dry weather flow water quality monitoring program was undertaken, the results of which are presented in Appendix E. The results for BOD and suspended solids were analysed and the hourly variations as indicated in Table 9 were determined and used as input parameters.

AVERAGE FLOW = 2.75 c.f.s.

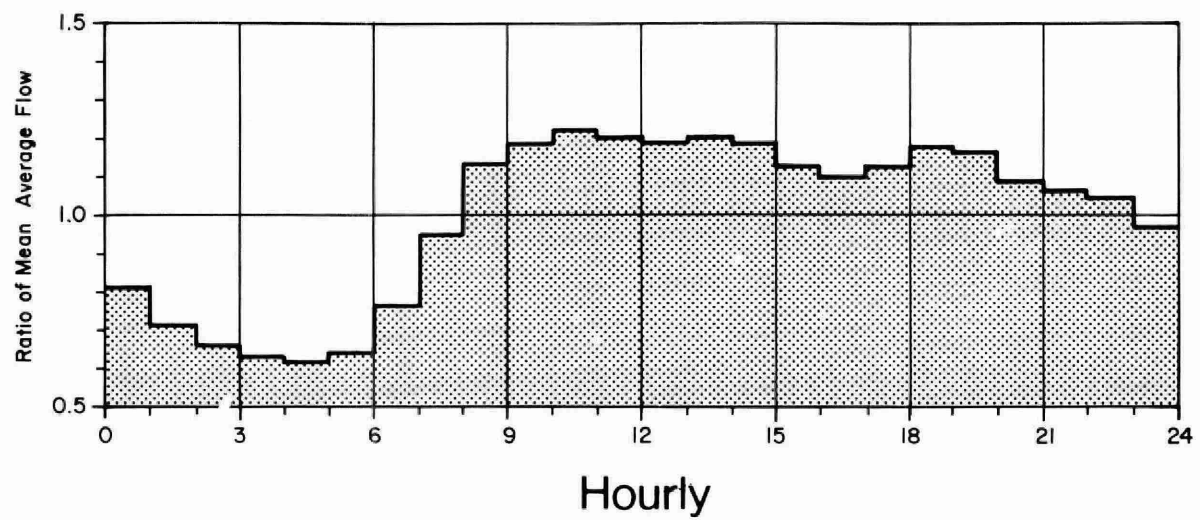
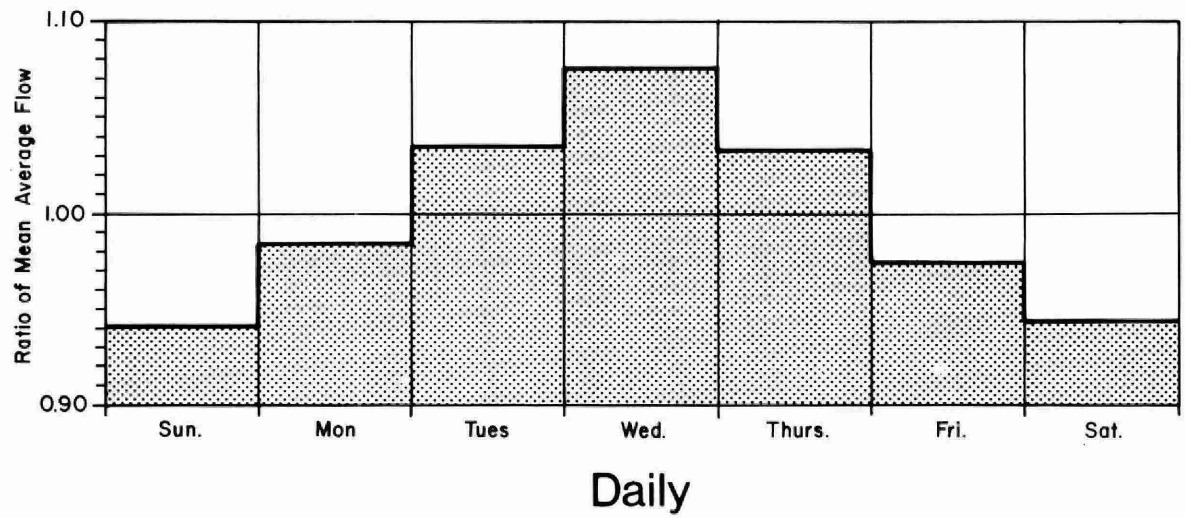


FIGURE 12. DRY WEATHER FLOW VARIATIONS

TABLE 9. DAILY AND HOURLY DRY WEATHER FLOW VARIATIONS

Day	RATIO OF AVERAGE		
	Dry Weather Flow (average 2.75 cfs)	BOD of Dry Weather Flow (average 95.3 mg/L)	SS of Dry Weather Flow (average 96.9 mg/L)
1 - Sunday	0.942	1.000	1.000
2 - Monday	0.985	1.000	1.000
3 - Tuesday	1.036	1.000	1.000
4 - Wednesday	1.076	1.000	1.000
5 - Thursday	1.033	1.000	1.000
6 - Friday	0.975	1.000	1.000
7 - Saturday	0.945	1.000	1.000
HOUR			
1	0.806	0.826	0.766
2	0.710	0.330	0.472
3	0.660	0.175	0.273
4	0.631	0.206	0.231
5	0.617	0.165	0.199
6	0.639	0.144	0.178
7	0.763	0.372	0.818
8	0.947	1.321	1.784
9	1.129	1.672	1.689
10	1.194	1.548	1.448
11	1.224	1.662	1.448
12	1.204	1.362	1.542
13	1.191	1.176	1.427
14	1.205	1.011	1.175
15	1.188	1.053	0.913
16	1.130	1.094	0.787
17	1.101	0.970	0.735
18	1.134	1.104	1.007
19	1.184	1.620	1.689
20	1.165	1.775	1.511
21	1.093	1.465	1.280
22	1.064	1.053	1.049
23	1.048	0.888	0.766
24	0.971	1.001	0.797

4. SIMULATIONS USING THE STORM WATER MANAGEMENT MODEL

4.1 Introduction

The main objective of this study was to duplicate the recorded precipitation-runoff events with the Runoff and Transport blocks of the Storm Water Management Model.

The Runoff block simulates both the quantity and quality runoff phenomena of a drainage basin, and the routing of flows and contaminants from selected subcatchment areas to major sewer lines which are modelled in the Transport block. By accepting an arbitrary hyetograph and making a sequential accounting of rainfall infiltration losses, surface retention, overland flow, gutter flow, and contaminants washed into the inlet manholes, the Runoff block calculates inlet hydrographs and pollutographs. The Transport block sets up pre-storm conditions by computing dry weather flow and infiltration and distributing them throughout the conveyance system. The Block then performs its primary function of flow and quality routing.

The computer program used in this particular study was the Canadian version of the U.S. Environmental Protection Agency's Storm Water Management Model, Release September 11, 1970, updated February 1975. The Canadian version was developed in a study sponsored by the Storm and Combined Sewers Subcommittee of the Canada-Ontario Agreement*.

4.2 Division of the Urban Catchment Area

Successful application of the SWMM requires that the urban test area be divided into a number of discrete subcatchment areas, whose hydrologic properties (e.g., pervious/impervious ratio, surface area, length and size of sewers, number of catch basins, and so on) can be reasonably accurately identified and quantified. The finer this division the more accurate will be the representation of the precipitation/runoff process. The manner in which this division was carried out in this study is shown in Table 10 and illustrated in Figure 13. As can be seen, the urban test area was divided into 33 subcatchments ranging in size from 4.32 acres

* Proctor and Redfern Ltd., and James F. MacLaren Ltd., "Storm Water Management Model Study", Volumes I, II and III, COA Research Reports No. 47, 48 and 62, Project No. 73-5-10, Ottawa, 1976.

TABLE 10. SUBCATCHMENT DATA

***** SUBCATCHMENT DATA *****																
SUBCATCH- MENT NO.	GUTTER OR INLET	WIDTH (FT)	AREA (AC)	UNCALIBRATED		CALIBRATED		SLOPE (FT/FT)	RESISTANCE FACTOR IMPERV.	SURFACE STORAGE(IN) IMPERV.	PERCENT IMPERV.	PERCENT IMPERV.	INFILTRATION		DECAY RATE (1/SEC)	GAGE NO.
				PERCENT IMPERV.	PERCENT IMPERV.	RATE(IN/HR) MAXIMUM	MINIMUM									
1	1	2	6054.0	20.9	53.2	42.4	0.004	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
2	2	2	1600.0	5.4	43.6	34.7	0.009	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
3	3	17	536.0	7.7	6.2	4.8	0.007	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
4	4	19	1950.0	25.9	40.7	32.5	0.011	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
5	5	300	1278.0	4.4	72.4	57.7	0.009	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
6	6	28	6645.0	22.1	46.7	37.2	0.014	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
7	7	3	1914.0	6.0	59.7	47.5	0.004	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
8	8	4	3423.0	10.0	49.6	39.5	0.010	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
9	9	22	2897.0	10.6	55.1	44.0	0.008	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
10	10	24	2688.0	10.5	40.3	32.1	0.009	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
11	11	25	1118.0	12.9	39.2	31.2	0.013	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
12	12	27	7130.0	22.1	49.6	39.6	0.006	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
13	13	304	3174.0	11.7	35.5	28.2	0.010	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
14	14	20	4019.0	12.9	49.1	39.2	0.005	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
15	15	307	5362.0	16.6	49.5	39.4	0.010	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
16	16	4	5600.0	18.6	48.3	38.5	0.008	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
17	17	7	2785.0	8.3	51.0	40.6	0.018	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
18	18	8	3707.0	11.5	71.1	56.7	0.015	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
19	19	9	4581.0	15.3	46.8	37.3	0.009	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
20	20	10	860.0	6.4	62.1	49.4	0.017	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
21	21	11	2233.0	10.0	78.3	62.4	0.017	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
22	22	29	1691.0	5.6	47.2	37.6	0.008	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
23	23	33	5781.0	16.2	41.5	33.0	0.015	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
24	24	8	1303.0	3.9	55.3	43.9	0.018	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
25	25	9	4306.0	13.8	51.1	40.8	0.014	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
26	26	11	1344.0	4.3	70.8	56.4	0.010	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
27	27	34	1429.0	4.4	51.9	41.3	0.007	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
28	28	35	3750.0	13.6	53.0	42.2	0.008	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
29	29	12	3015.0	9.7	52.0	41.4	0.013	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
30	30	306	2719.0	8.7	47.2	37.6	0.009	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
31	31	13	3646.0	11.3	49.0	39.0	0.019	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
32	32	15	2501.0	7.8	47.0	38.9	0.007	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
33	33	16	4409.0	14.2	48.6	36.8	0.009	0.013	0.250	0.020	0.184	3.00	0.52	0.00115	1	
TOTAL NUMBER OF SUBCATCHMENTS, 33																
TOTAL TRIBUTARY AREA (ACRES), 383.39																

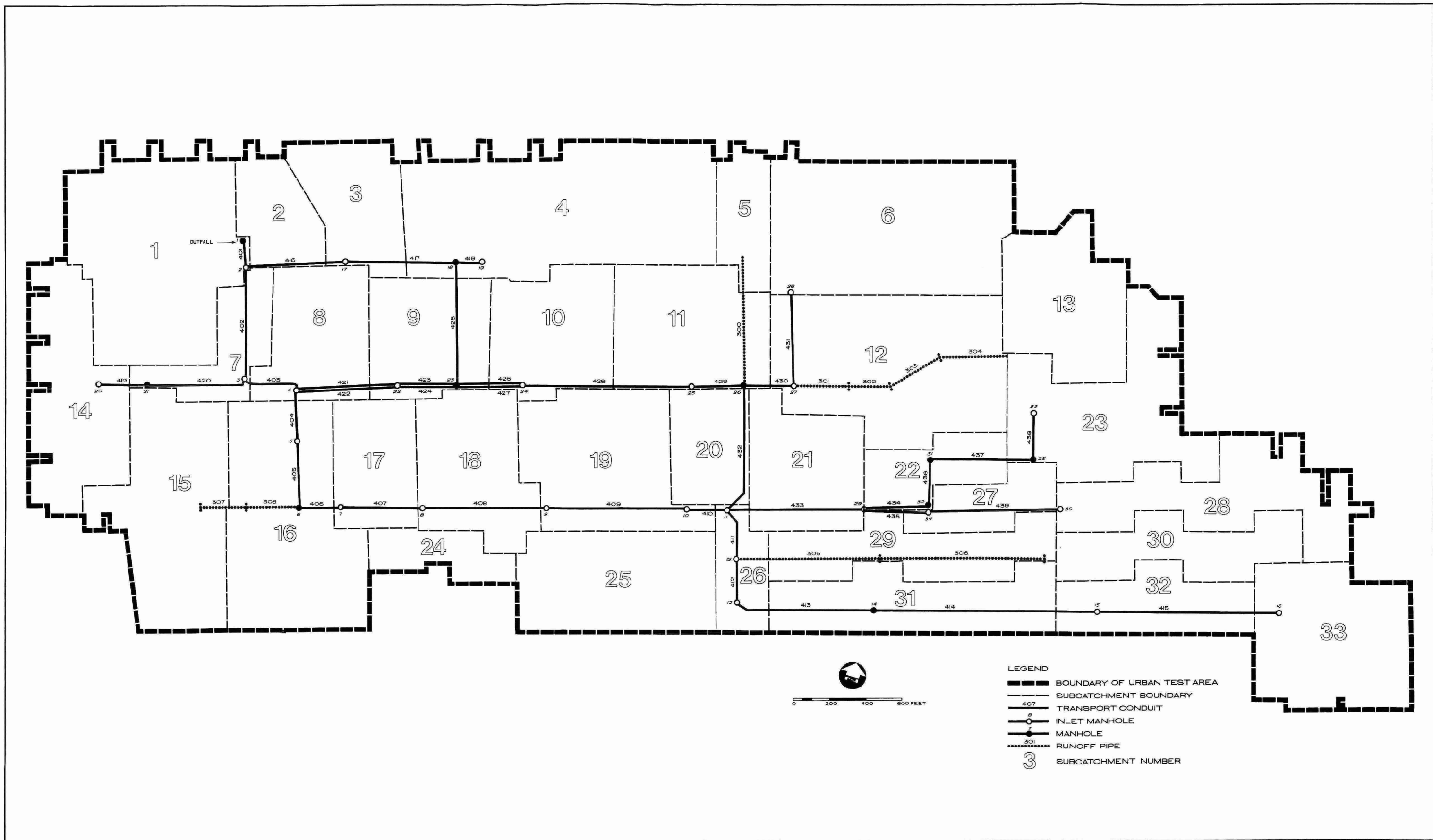


FIGURE 13. MAP SHOWING SUBDIVISION OF CATCHMENT AREA

to 25.91 acres. The sewer system is represented by nine pipe sections in the Runoff block and by 74 elements (39 pipe sections, 30 manholes and 5 flow dividers) in the Transport block. This results in about 72% of the actual sewer system volume being modelled. The sewer element input data for the Runoff block and Transport block have been included in Tables 11 and 12, respectively. It should be noted that Table 10 shows both the uncalibrated and calibrated values of the subcatchments' percent imperviousness.

TABLE 11. RUNOFF BLOCK PIPE DATA

* * * * * G U T T E R A N D P I P E D A T A * * * * *

GUTTER NUMBER	GUTTER CONNECTION	WIDTH (FT)	LENGTH (FT)	SLOPE (FT/FT)	SIDE SLOPES		MANNING N	OVERFLOW (IN)
					L	R		
1 *	304 303	1.0	364.	0.013	0.0	0.0	0.013	10.00
2 *	303 302	1.0	322.	0.008	0.0	0.0	0.013	10.00
3 *	302 301	1.5	157.	0.008	0.0	0.0	0.013	10.00
4 *	301 27	1.8	267.	0.005	0.0	0.0	0.013	10.00
5 *	306 305	1.8	934.	0.004	0.0	0.0	0.013	10.00
6 *	305 12	1.5	750.	0.014	0.0	0.0	0.013	10.00
7 *	300 26	1.3	641.	0.005	0.0	0.0	0.013	10.00
8 *	307 308	1.8	256.	0.014	0.0	0.0	0.013	10.00
9 *	308 6	2.0	285.	0.013	0.0	0.0	0.013	10.00
TOTAL NUMBER OF GUTTERS/PIPES, 9								
ASTERISK (*) DENOTES CIRCULAR PIPE, DIAMETER=.WIDTH.								

4.3 Calibration

The SWMM is designated as a "deterministic" model in that, if all input parameters are accurate, the physics of the processes are simulated sufficiently well to produce accurate results without calibration. In practice, however, many of the input parameters are not or cannot be accurately ascertained, thereby making it necessary to resort to default values which may not be representative of the study area. For this reason, verification of the SWMM requires a calibration process which entails the adjustment of input parameters until a good fit exists between the computed and measured hydrographs and pollutographs.

4.3.1 Quantity calibration

The input parameters that directly affect runoff volume are impervious area, width of overland flow, infiltration capacity of pervious

TABLE 12. TRANSPORT BLOCK SEWER ELEMENT DATA

EXT. ELE. NUM.	TYPE	DESCRIPTION	SLOPE (FT/FT)	DISTANCE (FT)	MANNING ROUGHNESS	GEOM1 (FT)	GEOM2 (FT)	GEOM3 (FT)	NUMBER OF BARRELS	AFULL (SQ.FT)	QFULL (CFS)	QMAX (CFS)	SUPER-CRITICAL FLOW WHEN LESS THAN 95% FULL?
16	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
415	1	CIRCULAR	0.0047	999.0	0.0130	2.0	0.0	0.0	1.0	3.142	15.551	16.795	NO
15	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
414	1	CIRCULAR	0.0073	1221.0	0.0130	2.0	0.0	0.0	1.0	3.142	19.381	20.931	NO
14	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
413	1	CIRCULAR	0.0037	769.0	0.0130	2.5	0.0	0.0	1.0	4.909	25.017	27.018	NO
13	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
412	1	CIRCULAR	0.0040	240.0	0.0130	3.0	0.0	0.0	1.0	7.069	42.297	45.681	NO
12	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
411	1	CIRCULAR	0.0054	299.0	0.0130	3.0	0.0	0.0	1.0	7.069	49.145	53.077	NO
11	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
33	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
438	1	CIRCULAR	0.0027	270.0	0.0130	2.0	0.0	0.0	1.0	3.142	11.787	12.729	NO
32	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
437	1	CIRCULAR	0.0028	560.0	0.0130	2.3	0.0	0.0	1.0	3.976	16.432	17.747	NO
31	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
436	1	CIRCULAR	0.0062	264.0	0.0130	2.0	0.0	0.0	1.0	3.142	17.861	19.290	NO
30	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
439	1	CIRCULAR	0.0027	566.0	0.0130	2.5	0.0	0.0	1.0	4.909	21.370	23.080	NO
35	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
434	1	CIRCULAR	0.0135	343.0	0.0130	2.0	0.0	0.0	1.0	3.142	26.356	28.464	NO
435	1	CIRCULAR	0.0057	346.0	0.0130	2.5	0.0	0.0	1.0	4.909	31.051	33.535	NO
34	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
29	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
433	1	CIRCULAR	0.0196	734.0	0.0130	2.5	0.0	0.0	1.0	4.909	57.579	62.185	NO
432	1	CIRCULAR	0.0102	707.0	0.0130	2.5	0.0	0.0	1.0	4.909	41.537	44.860	NO
410	1	CIRCULAR	0.0067	221.0	0.0130	3.8	0.0	0.0	1.0	11.045	99.254	107.194	NO
10	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
409	1	CIRCULAR	0.0083	765.0	0.0130	4.0	0.0	0.0	1.0	12.566	131.217	141.715	NO
9	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
408	1	CIRCULAR	0.0026	700.0	0.0130	5.0	0.0	0.0	1.0	19.635	133.158	143.810	NO
8	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
407	1	CIRCULAR	0.0038	451.0	0.0130	5.0	0.0	0.0	1.0	19.635	160.980	173.858	NO
7	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
406	1	CIRCULAR	0.0049	212.0	0.0130	5.0	0.0	0.0	1.0	19.635	182.800	197.424	NO
6	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
405	1	CIRCULAR	0.0049	380.0	0.0150	5.0	0.0	0.0	1.0	19.635	158.427	171.101	NO
5	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
404	1	CIRCULAR	0.0080	270.0	0.0150	5.0	0.0	0.0	1.0	19.635	202.431	218.625	NO
4	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
28	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
431	1	CIRCULAR	0.0085	510.0	0.0130	2.3	0.0	0.0	1.0	3.976	28.630	30.920	NO
27	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
430	1	CIRCULAR	0.0076	268.0	0.0130	2.5	0.0	0.0	1.0	4.909	35.854	38.722	NO
26	20	FLOW DIVIDER	88.6100	2.8	11.5000	0.5	3.0	429.0	1.0	0.0	0.0	0.0	
429	1	CIRCULAR	0.0050	285.0	0.0130	3.0	0.0	0.0	1.0	7.069	47.290	51.073	NO
25	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
428	1	CIRCULAR	0.0050	950.0	0.0130	3.3	0.0	0.0	1.0	8.296	58.542	63.225	NO
24	18	FLOW DIVIDER	0.0	0.0	0.0	8.0	0.0	426.0	1.0	0.0	0.0	0.0	
426	1	CIRCULAR	0.0154	335.0	0.0130	1.3	0.0	0.0	1.0	1.227	8.038	8.681	NO

TABLE 12. (CONT'D)

EXT. ELE. NUM.	TYPE	DESCRIPTION	SLOPE (FT/FT)	DISTANCE (FT)	MANNING ROUGHNESS	GEOM1 (FT)	GEOM2 (FT)	GEOM3 (FT)	NUMBER OF BARRELS	AFULL (SQ.FT)	QFULL (CFS)	QMAX (CFS)	SUPER-CRITICAL FLOW WHEN LESS THAN 95% FULL?
427	1	CIRCULAR	0.0050	325.0	0.0130	3.3	0.0	0.0	1.0	8.296	58.542	63.225	NO
23	18	FLOW DIVIDER	0.0	0.0	0.0	7.4	0.0	423.0	1.0	0.0	0.0	0.0	
423	1	CIRCULAR	0.0050	334.0	0.0130	1.5	0.0	0.0	1.0	1.767	7.448	8.043	NO
424	1	CIRCULAR	0.0052	348.0	0.0130	3.3	0.0	0.0	1.0	8.296	59.701	64.477	NO
22	18	FLOW DIVIDER	0.0	0.0	0.0	7.4	0.0	421.0	1.0	0.0	0.0	0.0	
421	1	CIRCULAR	0.0055	532.0	0.0130	2.0	0.0	0.0	1.0	3.142	16.822	18.168	NO
422	1	CIRCULAR	0.0052	532.0	0.0130	3.3	0.0	0.0	1.0	8.296	59.701	64.477	NO
425	1	CIRCULAR	0.0073	675.0	0.0130	1.8	0.0	0.0	1.0	2.405	13.574	14.660	NO
403	1	CIRCULAR	0.0053	320.0	0.0150	5.5	0.0	0.0	1.0	23.758	212.447	229.442	NO
3	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
20	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
419	1	CIRCULAR	0.0037	253.0	0.0130	2.0	0.0	0.0	1.0	3.142	13.798	14.902	NO
21	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
420	1	CIRCULAR	0.0025	557.0	0.0130	2.3	0.0	0.0	1.0	3.976	15.527	16.769	NO
402	1	CIRCULAR	0.0053	630.0	0.0150	5.5	0.0	0.0	1.0	23.758	212.447	229.442	NO
2	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
19	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
418	1	CIRCULAR	0.0075	163.0	0.0130	2.0	0.0	0.0	1.0	3.142	19.644	21.216	NO
18	20	FLOW DIVIDER	28.0300	0.6	6.5000	0.3	2.0	417.0	1.0	0.0	0.0	0.0	
417	1	CIRCULAR	0.0041	615.0	0.0130	2.0	0.0	0.0	1.0	3.142	14.524	15.686	NO
17	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	
416	1	CIRCULAR	0.0046	551.0	0.0130	2.0	0.0	0.0	1.0	3.142	15.385	16.615	NO
401	1	CIRCULAR	0.0078	100.0	0.0150	5.5	0.0	0.0	1.0	23.758	257.726	278.344	NO
1	16	MANHOLE	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	

areas, surface depressional storage, Manning's 'n', and ground slope. The factor which has by far the greatest effect is the percent imperviousness. Although this is a measurable input parameter, it still requires a certain amount of adjustment in order to account for such factors as (i) errors in estimating surface areas from an aerial photograph and (ii) loss of runoff from impervious areas which are directly connected to pervious areas.

The first rainfall-runoff event chosen for calibration purposes occurred on June 25, 1976. The storm was of fairly long duration but the rainfall intensities did not exceed the expected infiltration capacity of the pervious areas. It was therefore safe to assume that only the impervious area contributed to runoff. As a result, the number of variable input parameters were substantially reduced.

For the calibration, the input parameters that could not be determined directly were assumed to be equal to the default values of the model with one exception, the surface depressional storage. This was set equal to 0.02 inches, as opposed to the default value of 0.062 inches, on the strength of a rainfall-runoff analysis and other verification studies in Canada. To achieve the fit as shown in Figure 14, however, the initial values of the subcatchment impervious areas had to be adjusted from 187 acres (i.e., 49% impervious - refer to Section 2.2) to 150 acres (i.e., 39.1% impervious). This discrepancy between measured and calibrated impervious areas can be attributed to those impervious areas which are directly connected to pervious areas (e.g., sheds, driveways, etc).

Although the storm on June 25, 1976 was suited for quantity calibration, it could not be used for quality calibration as no runoff quality data were collected. Therefore the rainfall-runoff event on July 7, 1976, which could be used for both quantity and quality calibration, was chosen as an additional calibration event. Using the aforementioned calibration input parameters a good fit was achieved (see Figure 1a) which indicated that no further calibration was likely to be required.

The quantity calibration just described was carried out at the end of the first data collection period. Unfortunately, most of the recorded precipitation during this period was not of sufficiently high intensity to overcome the estimated and modelled infiltration and

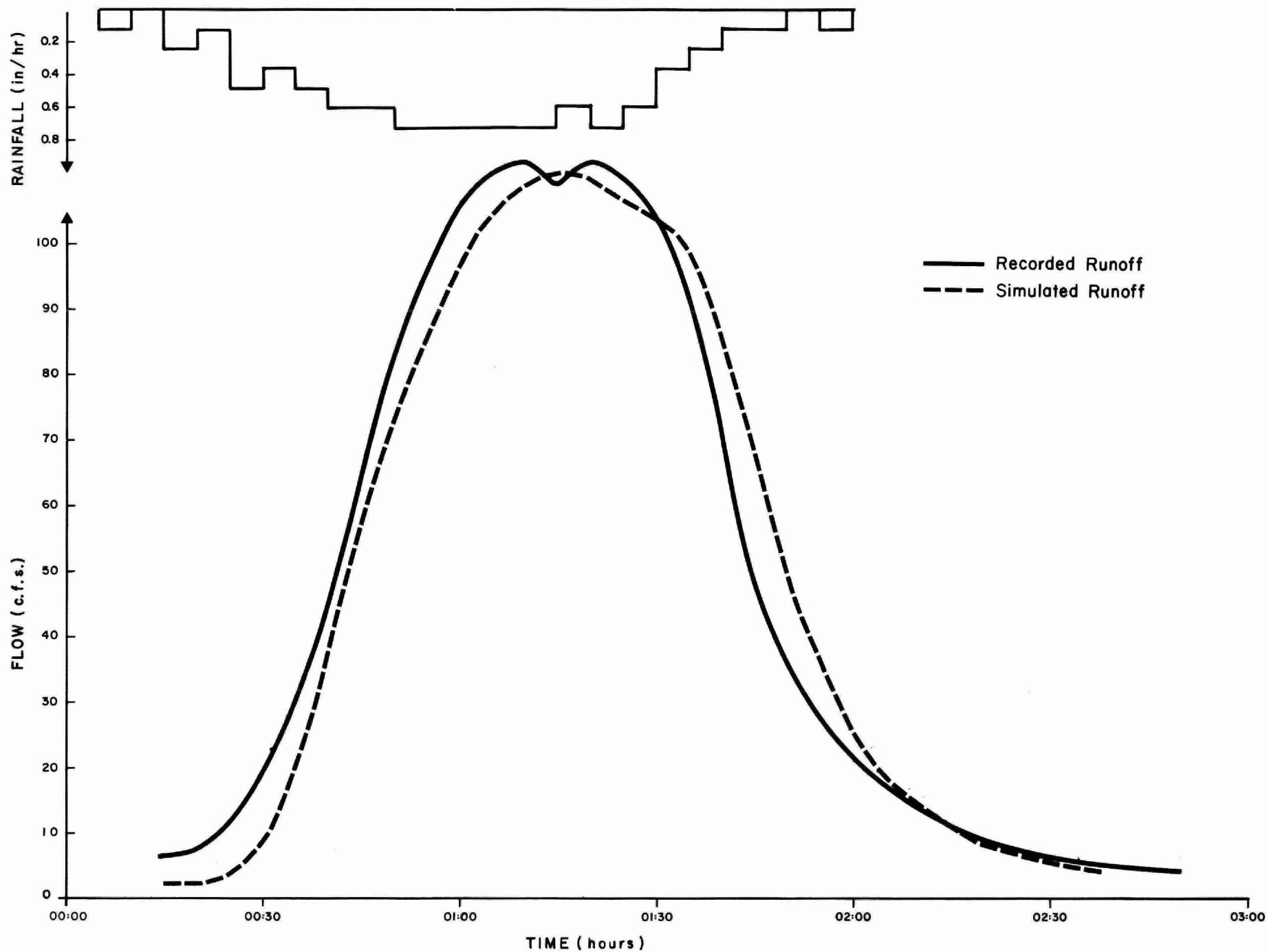


FIGURE 14. COMPARISON OF RECORDED AND SIMULATED RUNOFF - STORM OF JUNE 25, 1976

depressional storage losses of pervious areas. This meant that virtually all runoff originated from the impervious areas. This conclusion was confirmed by the ratios of the recorded volume to the precipitation volume (Figure 15), which varied from 0.27 to 0.44 with an average value of 0.36. This figure compares favourably with the modelled ratio of directly connected impervious areas to total area of 0.39. It was therefore not possible to calibrate and/or verify the SWMM default values related to pervious areas (e.g., infiltration, depressional storage, etc.).

During the second data collection period, however, rainfall-runoff data were collected on three storms with fairly high intensity rainfalls, and attempts were made to calibrate the pervious area input parameters. The storms occurred on June 25, June 29 and August 10, 1977, and their respective recorded hyetographs and resultant hydrographs are presented in Appendix C (Figures XXIX, XXX, and XXXI). In all, 11 runs were made in which only the pervious area depression storage and the maximum and minimum infiltration values were varied. The actual values chosen for each run, together with the simulated hydrograph results are given in Table 13. Brief comments on the findings for each storm follow.

- i) Storm on June 25, 1977 - Variation of the depressional storage and the minimum infiltration values had little effect on the simulated hydrographs. No justification could be found for decreasing the maximum infiltration value since the rainfall during the previous five days was negligible; but it would, in all likelihood, have made little difference. Figure XXIX shows that the fit achieved is fairly good, with the volume and peak being underestimated by 15% and 12%, respectively.
- ii) Storm on July 29, 1977 - As can be seen from Figure XXX, the resultant hydrograph has two peaks. Although variation of input parameters had little effect on the first peak, it did have a noticeable effect on the second peak. The best overall fit for the second peak was achieved with a minimum infiltration value of 0.4 inches per hour. The simulated hydrograph underestimated the volume by 18%, the first peak by 20% and the second peak by 17%.

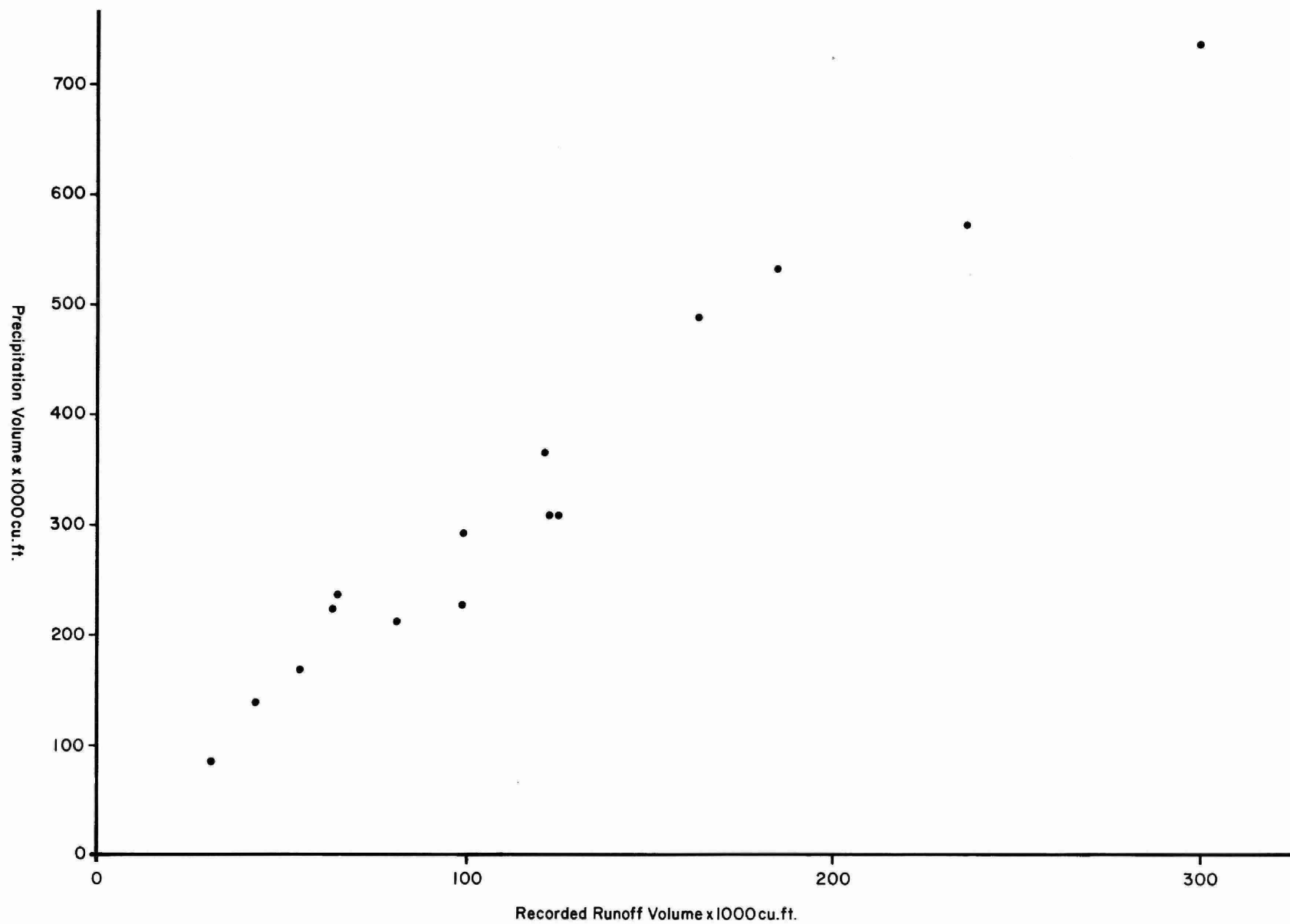


FIGURE 15. PRECIPITATION VOLUME VS RECORDED RUNOFF VOLUME

TABLE 13. RESULTS OF ATTEMPTS TO CALIBRATE INPUT PARAMETERS RELATING TO PERVIOUS AREAS

Storm Date	Previous 5-day Rainfall (inches)	Simulation Run	Varied Input Parameters Relating to Pervious Areas			Hydrograph Results					
						Flow Volume (cf)		Peak Runoff (cfs)		Time to Peak* (min)	
			Depression Storage (inches)	Maximum Infiltration (in/hr)	Minimum Infiltration (in/hr)	Recorded	Simulated	Recorded	Simulated	Recorded	Simulated
25/06/77	0.07	1	0.184	3.00	0.52	426 720	363 275	225	197	18	20
		2	0.050	3.00	0.52		363 405		197		20
		3	0.020	3.00	0.52		367 220		201		20
		4 **	0.100	3.00	0.52		363 275		197		20
		5	0.100	3.00	0.25		363 275		197		20
29/06/77	0.75	1	0.184	3.00	0.52	641 760	516 200	i) 243 ii) 135	i) 192	i) 19 ii) 114	i) 20
									ii) 110		ii) 105
		2	0.100	3.00	0.25		572 085		i) 192		i) 20
									ii) 121		ii) 115
		3	0.100	3.00	0.52		517 080		i) 192		i) 20
									ii) 110		ii) 110
		4 **	0.100	1.50	0.40		528 235		i) 193		i) 20
									ii) 112		ii) 110
10/08/77	2.06	1	0.184	3.00	0.52	262 320	231 990	218	172	20	20
		2**	0.100	0.40	0.40		267 975		182		20

* Time to peak is from start of precipitation.

**Best visual fit - compared to recorded hydrographs in Figures.

- iii) Storm on August 10, 1977 - Two runs were made for this storm. The first with the SWMM default values and the second using the most promising input parameters abstracted from the nine runs for the previous storms. The second run gave a very good fit (refer to Figure XXXI), with the volume being overestimated by 2% and the peak underestimated by 12%. It should be noted that the reason for having chosen a maximum infiltration value of 0.4 inches per hour (the same value as the minimum infiltration value) was because the pervious areas were considered to be highly saturated, a result of the large rainfall (2.06") in the previous five days, 0.53" of which occurred in the previous 14 hours.

From these studies it appears that the most promising values for the pervious area depression storage and for the minimum infiltration rate were 0.1" and 0.4", respectively. No "best value" for the maximum infiltration rate could be ascertained; it was felt that this would vary according to the antecedent moisture conditions of the ground. The simulated results underestimated the volume in two of the storms and the peak flow in all three storms. This could be due to a variety of reasons the more probable being one or a combination of both of the following:

- i) an under-catching tendency of the precipitation gauge for high intensity rainfalls; or
- ii) incorrect calibrated input parameters from the storms recorded during the first data collection period, since only runoff from impervious areas could be simulated because of low intensity storms.

An unsuccessful attempt was made to calibrate the model for the rainfall-snowmelt event on January 26, 1976. Despite many runs with various input parameters, the simulated volume of runoff always substantially exceeded the recorded volume of runoff. It was concluded that this phenomenon was due to one or a combination of the following factors:

- i) Water which was held back in "ponds" due to snow and ice blockages, an occurrence which was verified by field observations.
- ii) Incorrect assumptions in attempting to account for artificial redistribution of snow in urban areas; for example, snow removal and snowmelt induced by artificial heat (roof melt).

- iii) The assumption that the precipitation gauge measured rainfall only. It could have been recording rainfall together with the melting of old accumulated snow in the collecting funnel.
- iv) Incorrect assessment of snow distribution and its water equivalent on both pervious and impervious areas.

4.3.2 Quality calibration

To simulate the water quality of the runoff many input parameters in addition to those for simulating quantity are required. Some of these must be determined and supplied by the user, while others may be supplied as options to default values built into the model. Input data for this particular study for both the Runoff and Transport blocks together with calibrated, assigned, or referenced values are presented in Tables 14 to 16.

As a prerequisite to the quality calibration process it is necessary to ensure that the simulated and recorded hydrographs of the selected precipitation runoff event are in good agreement. For this reason the first event chosen for calibration was the quantity calibration storm of July 7, 1976. The calibration runs for this storm indicated that (i) varying the BOD concentration of catch basins within reasonable limits had little effect and (ii) the empirical option (ISS=1) for suspended solids calculations produced better results than the use of the exponential equation (ISS=0). As the number of dry days before the storm was less than 10, this agrees with the results of an earlier study* which concluded that the empirical equation (ISS=1) would generally give better results when the number of dry days preceding the storm event was less than 10 to 15. As most of the recorded storms available for verification fell into this category, the empirical option of ISS=1 was adopted.

An important aspect of simulating the water quality of real storm events is the consideration that must be given to the method by which the

* Proctor and Redfern Ltd., and James F. MacLaren Ltd., "Storm Water Management Model Study", Volumes I, II and III, COA Research Reports No. 47, 48 and 62, Project No. 73-5-10, Ottawa, 1976.

TABLE 14. QUALITY INPUT DATA

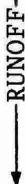
BLOCK	INPUT PARAMETER	ASSIGNED OR REFERENCED VALUES
  RUNOFF	Number of dry days before storm	Refer to Section 4.3.2 and Table 15
	Street sweeping frequency	Refer to Section 4.3.2 and Table 15
	Number of street sweeper passes	1
	Catch basin storage volume	13 cubic feet
	Concentration of BOD in catch basin	100 mg/L
	Method of calculating SS	ISS = 1
	Subcatchment data	Refer to Table 16
	Dust and dirt accumulation rates	Default values
  TRANSPORT	Fraction of pollutant in dust and dirt	Default values
	Number of dry weather days before storm	Refer to Table 15
	Daily flow variation	Refer to Figure 12 and Table 9
	Daily BOD variation	Default values
	Daily SS variation	Default values
	Hourly flow variation	Refer to Figure 12 and Table 9
	Hourly BOD variation	Refer to Table 9
	Hourly SS variation	Refer to Table 9
	Total population	14,600
	Total average sewage flow	2.75 cfs
	Total average BOD	95.3 mg/L
	Total average SS	96.9 mg/L
	Total contributing industrial area	0
	Total contributing commercial area	25.7 acres
	Total contributing high income area	85.4 acres
	Total contributing av. income area	239.1 acres
	Total contributing low income area	17.1 acres
	Total area with garbage grinders	0
	Total park and open space area	16.1 acres
	Subcatchment data	Refer to Table 16

TABLE 15. VARIABLE QUALITY INPUT PARAMETERS

Storm Date	Number of dry days prior to storm in which cumulative rainfall is less than 1 inch	Number of equivalent days of pollutant accumulation (refer to Section 4.3.2 in text)	Number of days prior to simulation during which solids were not flushed from sewers
27/03/76	17	17	2.0
31/03/76	19	2	3.5
22/04/76	7	3	1.0
24/04/76	9	5	2.0
11/05/76	5	5	0.5
01/06/76	16	9	0.5
28/06/76	3	3	1.0
30/06/76	5	5	1.5
01/07/76	5	5	1.0
01/07/76	5	5	0.5
02/07/76	6	6	0.5
07/07/76	7	3	4.0
11/07/76	10	6	1.0
20/07/76	19	4	1.0
29/07/76	19	4	0.5
31/07/76	11	6	2.0
13/08/76	13	5	1.0
01/09/76	3	3	3.0

TABLE 16. QUALITY SUBCATCHMENT DATA

Subcatchment Number*	RUNOFF BLOCK				TRANSPORT BLOCK					
	Land Use Classification	Number of Catch Basins	Gutter Length in Hundreds of Feet	Predominant Land Use	Subcatchment Area (acres)	Population Density (persons/acre)	Total Number of Dwelling Units	Number of People Living in Average Dwelling Unit	Market Value of Average Dwelling Unit	% of Dwelling Units with Garbage Grinders
1	1	19	78.8	1	REFER TO TABLE 10	35	164	4.5	60	0
2	1	7	26.9	1		30	45	3.6	60	
3	5	2	10.5	5		0	0	0	0	
4	1	36	108.8	1		30	192	4.0	60	
5	1	6	19.7	1		30	36	3.7	60	
6	1	32	95.7	1		35	176	4.4	60	
7	1	7	26.9	1		30	52	3.5	60	
8	1	12	37.9	1		30	192	2.7	40	
9	1	15	39.7	1		30	67	4.8	60	
10	1	12	38.1	1		40	92	4.6	40	
11	5	14	35.9	5		0	0	0	0	
12	1	35	80.8	1		30	184	3.6	60	
13	1	12	45.4	1		40	110	4.2	40	
14	1	15	46.9	1		55	154	4.6	40	
15	1	27	66.2	1		55	218	4.2	60	
16	1	28	64.1	1		60	224	5.0	40	
17	1	10	32.4	1		60	127	3.9	40	
18	1	11	38.2	1		50	135	4.3	40	
19	1	19	56.4	1		40	181	4.4	60	
20	3	4	12.9	2		0	0	0	0	
21	3	4	12.7	2		0	0	0	0	
22	1	10	28.3	1		30	50	3.4	60	
23	1	21	70.7	1		35	177	3.2	40	
24	1	8	17.6	1		55	48	4.6	40	
25	1	14	52.0	1		50	183	3.8	40	
26	1	12	22.7	1		60	37	7.0	60	
27	1	4	18.0	1		30	56	2.4	40	
28	1	19	53.7	1		30	162	2.5	40	
29	1	13	39.6	1		60	138	4.2	40	
30	1	10	31.9	1		50	110	4.0	40	
31	1	17	45.0	1		60	174	3.9	40	
32	1	8	28.6	1		50	111	3.5	40	
33	1	18	52.4	1		50	152	4.7	40	

* The Runoff block subcatchments correspond to the Transport block subcatchments in this particular study.

model computes the dust and dirt accumulation from the number of dry days and the street sweeping frequency. The model cannot cope with the situation where the actual storm occurs in the middle of the street sweeping interval, neither can it take into account an irregular street sweeping frequency. In this particular study, the actual dates of street cleaning activities were recorded (refer to Tables 2 and 3); consequently, a method was developed to overcome the problem. The method entailed calculating the number of equivalent days of pollutant accumulation from the time of the last storm to the storm under consideration taking into account the street sweepings during that period. The time of the last storm was taken as the time when the accumulative rainfall prior to the storm under consideration amounted to one inch. The equation adopted for working out the total number of equivalent days of pollutant accumulation (N_D) is as follows:

$$N_D = t_1(1-E)^{n-1} + t_2(1-E)^{n-2} + t_3(1-E)^{n-3} + \dots + t_n(1-E)^{n-n}$$

where: t = time interval in days between street sweeping and/or between storm and street sweeping,

E = efficiency of the street sweeping (in this study assumed to be 0.75), and

n = number of time intervals between storms.

The application of this empirical equation can best be illustrated by the following example:

For the July 31, 1976 storm the number of dry days prior to the storm in which the accumulated rainfall was less than 1 inch was 11. Therefore, date of last storm was assumed to have occurred on July 20; street sweeping took place on July 21 and July 27. This gives rise to the following three time intervals:

$t_1 = 1$ (number of days between end of last storm and first street sweeping event),

$t_2 = 6$ (number of days between first sweeping event and second sweeping event),

$t_3 = 4$ (number of days between second sweeping event and storm under consideration).

$$N_D = 1 \times 0.25^2 + 6 \times 0.25 + 4 = 5.56, \text{ say } \underline{6}.$$

Table 15 presents the results of this special method and compares them with the number of dry days prior to the storm in which the accumulative rainfall is less than 1 inch.

Using this method, the total number of equivalent days of pollutant accumulation becomes, for input data purposes, the number of dry days prior to the storm in which the cumulative rainfall is less than 1 inch. In making this substitution, however, a hypothetical street sweeping frequency greater than the number of dry days must be inserted to ensure that street sweeping is not accounted for again in the actual program.

The simulated BOD and SS pollutographs for the July 7, 1976 storm, using the input data presented in Table 14, are shown on Figures 1b and 1c, respectively. Although the match with the recorded pollutographs cannot be described as good, it does reflect a great improvement over the initial calibration runs when no special consideration had been given to the method of computing the dust and dirt accumulation.

The storm on May 11, 1976, was selected as the second calibration storm. Although the results (refer to Figures XIb and VIc) were no more encouraging than those for the July 7, 1976 storm, they did show a very similar trend. Both simulated BOD pollutographs could have achieved a fairly good fit with a time displacement in the region of +15 to +20 minutes, and both simulated SS pollutographs would have achieved an excellent fit if all simulated values were reduced by about 40%.

After examining the results of the various calibration runs for the storms on July 7 and May 11, 1976, it was felt that the calibration results presented in this report were reasonable and could not be improved upon without major changes to the default values for the dust and dirt loading rates, and for pollutant composition. As there were no field data available to justify or confirm the need for such changes, it was decided to terminate the calibration process and to treat the remaining storms as verification runs.

4.4 Verification

Nineteen of the storms listed in Table 7 were selected for verification runs. The time steps and rainfall intervals were five minutes for all the runs.

4.4.1 Quantity verification

The simulated hydrographs of the verification runs are compared to the recorded hydrographs in Figures Ia to XVIIa. In addition, a summary of the verification results is presented in Tables 17 to 19 and Figures 16 to 18. As can be seen the results were most encouraging. It should be noted, however, that they only verified runoff from impervious areas due to the reasons mentioned in Section 4.3.1. The results are summarized below.

- i) The runoff volumes were simulated fairly accurately (refer to Table 17 and Figure 16). The average ratio of simulated to recorded flow volumes was 0.968 with a standard deviation of 0.780. About 100%, 81% and 44% of the simulated flow volumes were within 20%, 10% and 5% of the recorded flow volumes, respectively.
- ii) The peak flow rates were also simulated fairly accurately (refer to Table 18 and Figure 17). The average ratio of simulated to recorded peak flow rates was 1.019 with a standard deviation of 0.119. About 91%, 59% and 34% of the simulated peaks were within 20%, 10% and 5% of the recorded peaks, respectively.
- iii) The time to peak simulations were considered very accurate (refer to Table 19 and Figure 18). The average ratio of simulated to recorded time to peak was 1.028 with a standard deviation of 0.078. About 97%, 88% and 72% of the simulated times to peak were within 20%, 10% and 5% of the recorded times to peak, respectively.

A point worthy of note is that, as combined sewers were being modelled, the simulated hydrographs had to include dry weather flow (DWF). There was no way of ascertaining the actual magnitude of the DWF during each storm event. The average results from the dry weather flow analyses presented in Table 9 and Figure 12 were used, therefore, in the simulation of the hydrographs. This approximation would introduce small errors into the verification results. Provided the contribution of the DWF was small with respect to the total runoff these errors would be insignificant. For some of the storm events simulated in this study, however, the DWF makes a substantial contribution to the total hydrograph. In the storm of June 28, 1976, for example, as much as 40% of the total volume of simulated

TABLE 17. COMPARISON OF SIMULATED AND RECORDED FLOW VOLUMES*

Storm Date	Simulated Flow Volume (cf)	Recorded Flow Volume (cf)	Ratio of Simulated to Recorded Flow Volume
27/03/76	114 100	138 700	0.823
31/03/76	301 600	321 200	0.939
22/04/76	54 800	63 100	0.868
25/04/76	171 500	175 800	0.976
11/05/76	97 200	102 900	0.945
01/06/76	72 700	73 500	0.989
28/06/76	53 400	54 900	0.973
30/06/76	257 400	244 200	1.054
01/07/76	109 900	95 200	1.154
01/07/76	132 400	141 000	0.939
02/07/76	93 200	89 500	1.041
11/07/76	75 100	81 000	0.927
20/07/76	344 000	372 200	0.924
31/07/76	249 100	250 100	0.996
13/08/76	129 600	143 200	0.905
01/09/76	123 800	119 300	1.038

Number of rainfall events = 16

Mean of $\frac{\text{Simulated}}{\text{Recorded}}$ Flow Volumes = 0.968

Standard Deviation of $\frac{\text{Simulated}}{\text{Recorded}}$ Flow Volumes = 0.078

* Flow volume is comprised of storm runoff and DWF.

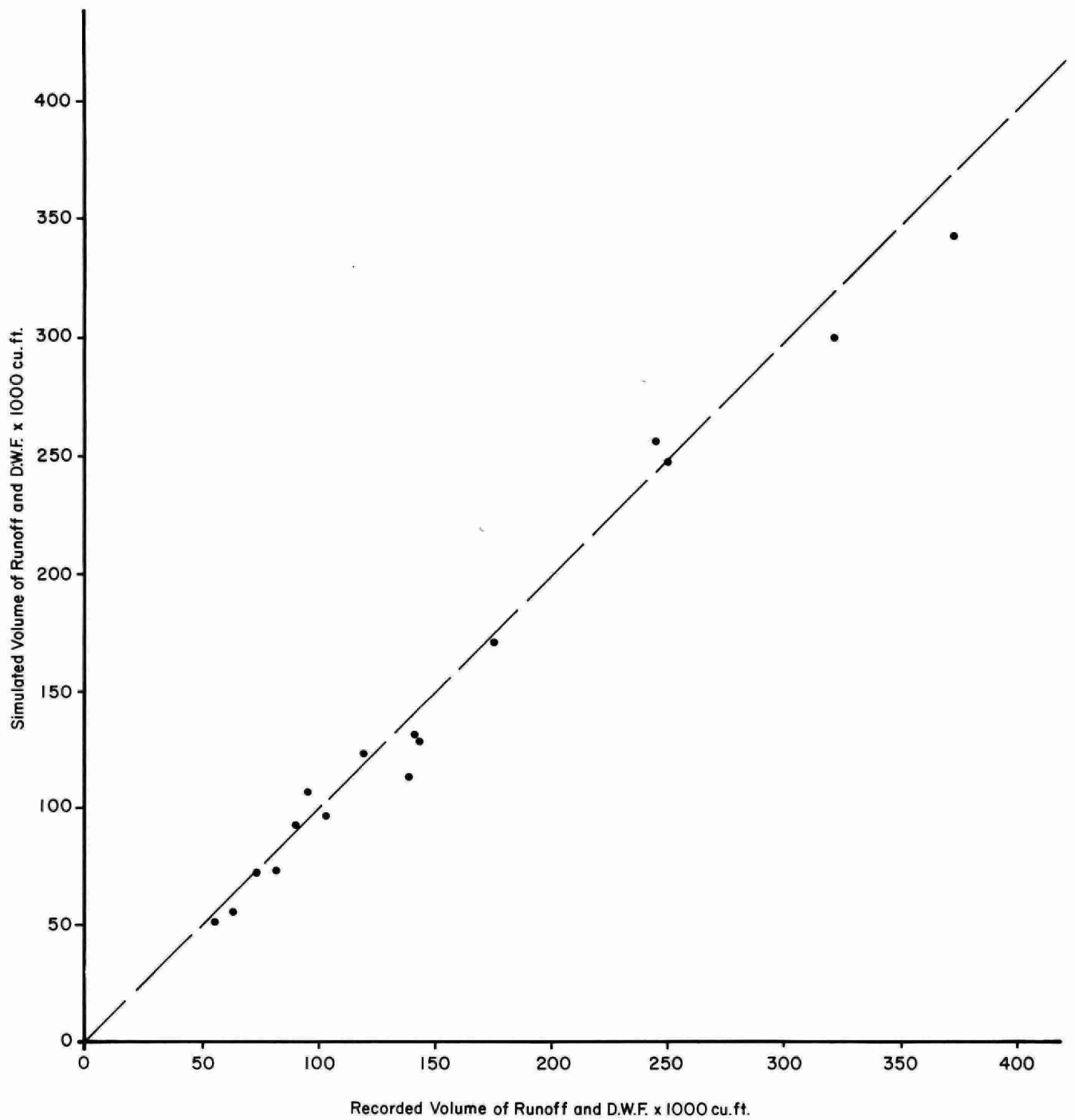


FIGURE 16. SWMM VERIFICATION RESULTS - SIMULATED VS
RECORDED VOLUME OF RUNOFF AND DWF

TABLE 18. COMPARISON OF SIMULATED AND RECORDED PEAK RUNOFFS

Storm Date		Simulated Peak Flow (cf)	Recorded Peak Flow (cf)	Ratio of Simulated to Recorded Peak Flows
27/03/76	(i)	23.3	29.3	0.795
	(ii)	25.0	25.5	0.980
31/03/76	(i)	15.0	14.5	1.034
	(ii)	17.0	17.0	1.000
	(iii)	21.5	21.1	1.019
	(iv)	25.8	25.0	1.032
22/04/76		20.0	22.4	0.893
25/04/76	(i)	24.0	20.0	1.200
	(ii)	16.7	17.0	0.982
11/05/76		38.3	35.8	1.070
01/06/76		25.5	22.9	1.115
28/06/76		22.5	19.0	1.184
30/06/76	(i)	41.4	37.0	1.119
	(ii)	23.0	20.0	1.150
01/07/76		37.9	30.0	1.263
01/07/76		105.0	111.0	0.946
02/07/76		23.3	22.9	1.017
11/07/76		20.3	19.0	1.068
20/07/76	(i)	27.0	24.0	1.125
	(ii)	59.0	61.3	0.962
	(iii)	49.5	55.2	0.897
29/07/76	(i)	40.5	41.5	0.976
	(ii)	31.5	29.5	1.068
31/07/76	(i)	44.0	40.0	1.100
	(ii)	18.0	20.0	0.900
	(iii)	35.9	28.5	1.260
	(iv)	24.0	30.0	0.800
	(v)	21.2	23.2	0.914
	(vi)	23.2	26.6	0.872
13/08/76		112.0	121.0	0.926
01/09/76	(i)	61.0	64.0	0.953
	(ii)	22.0	22.5	0.978

Number of peak flows = 32

Mean of $\frac{\text{Simulated}}{\text{Recorded}}$ peak flows = 1.019

Standard Deviation $\frac{\text{Simulated}}{\text{Recorded}}$ peak flows = 0.119

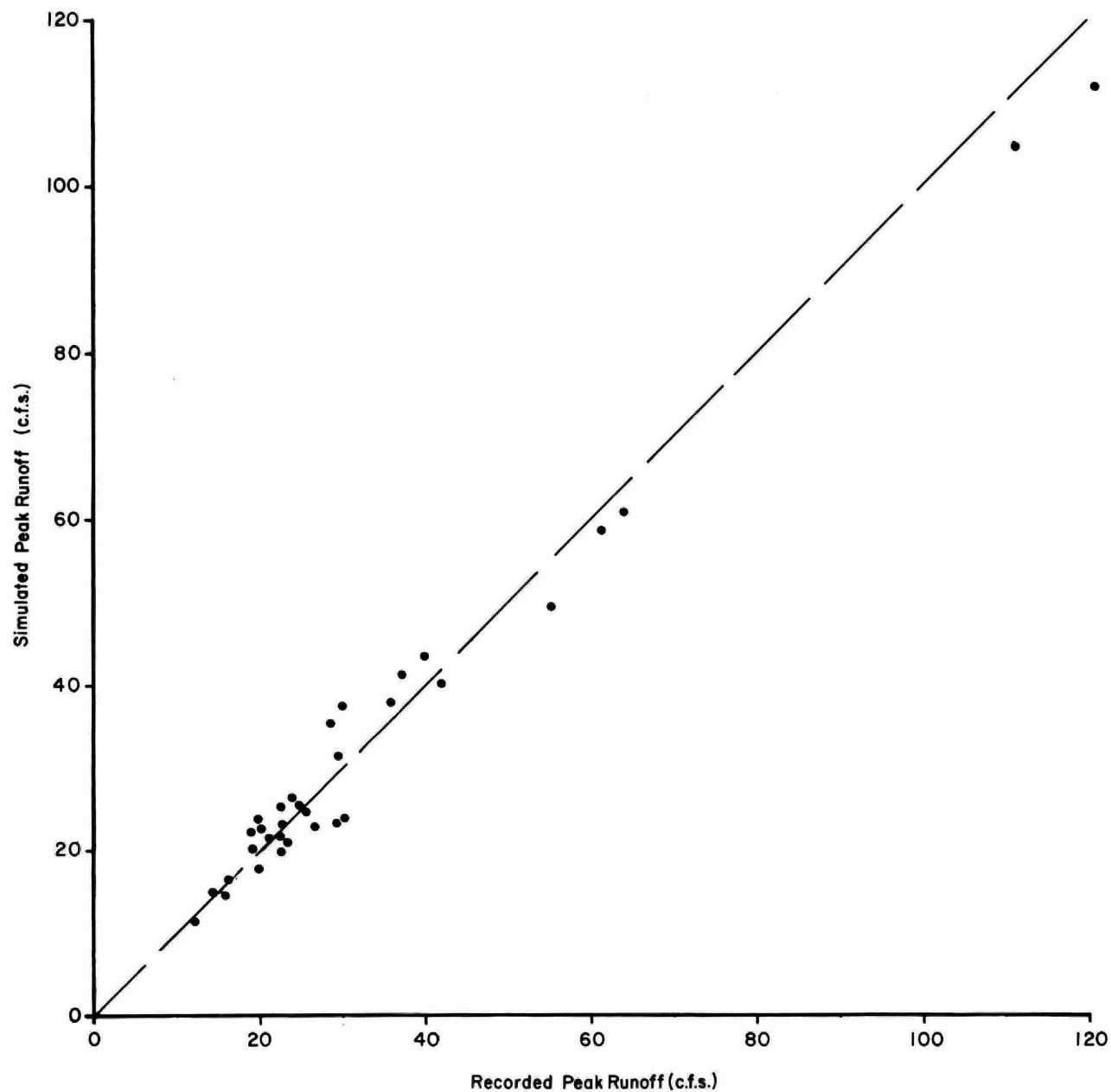


FIGURE 17. SWMM VERIFICATION RESULTS - SIMULATED VS RECORDED PEAK RUNOFF

TABLE 19. COMPARISON OF SIMULATED AND RECORDED TIMES TO PEAK*

Storm Date		Simulated Time to Peak (min)	Recorded Time to Peak (min)	Ratio of Simulated To Recorded Time to Peak
27/03/76	(i)	24	22	1.091
	(ii)	79	78	1.013
31/03/76	(i)	56	55	1.018
	(ii)	140	134	1.045
	(iii)	195	191	1.021
	(iv)	297	298	0.997
22/04/76		39	38	1.026
25/04/76	(i)	96	98	0.980
	(ii)	227	227	1.000
11/05/76		37	45	0.822
01/06/76		29	26	1.115
28/06/76		31	33	0.939
30/06/76	(i)	125	123	1.016
	(ii)	275	275	1.000
01/07/76		53	55	0.964
01/07/76		18	16	1.125
02/07/76		138	141	0.979
11/07/76		60	60	1.000
20/07/76	(i)	50	48	1.042
	(ii)	141	136	1.037
	(iii)	175	170	1.029
29/07/76	(i)	73	72	1.014
	(ii)	125	124	1.008
31/07/76	(i)	35	32	1.094
	(ii)	75	69	1.087
	(iii)	96	96	1.000
	(iv)	115	115	1.000
	(v)	155	153	1.013
	(vi)	173	171	1.012
13/08/76		20	15	1.333
01/09/76	(i)	49	46	1.065
	(ii)	83	82	1.012

Number of times to peak = 32

Mean of $\frac{\text{Simulated}}{\text{Recorded}}$ Times to Peak = 1.028

Standard Deviation $\frac{\text{Simulated}}{\text{Recorded}}$ Times to Peak = 0.078

* Time to peak is from start of precipitation.

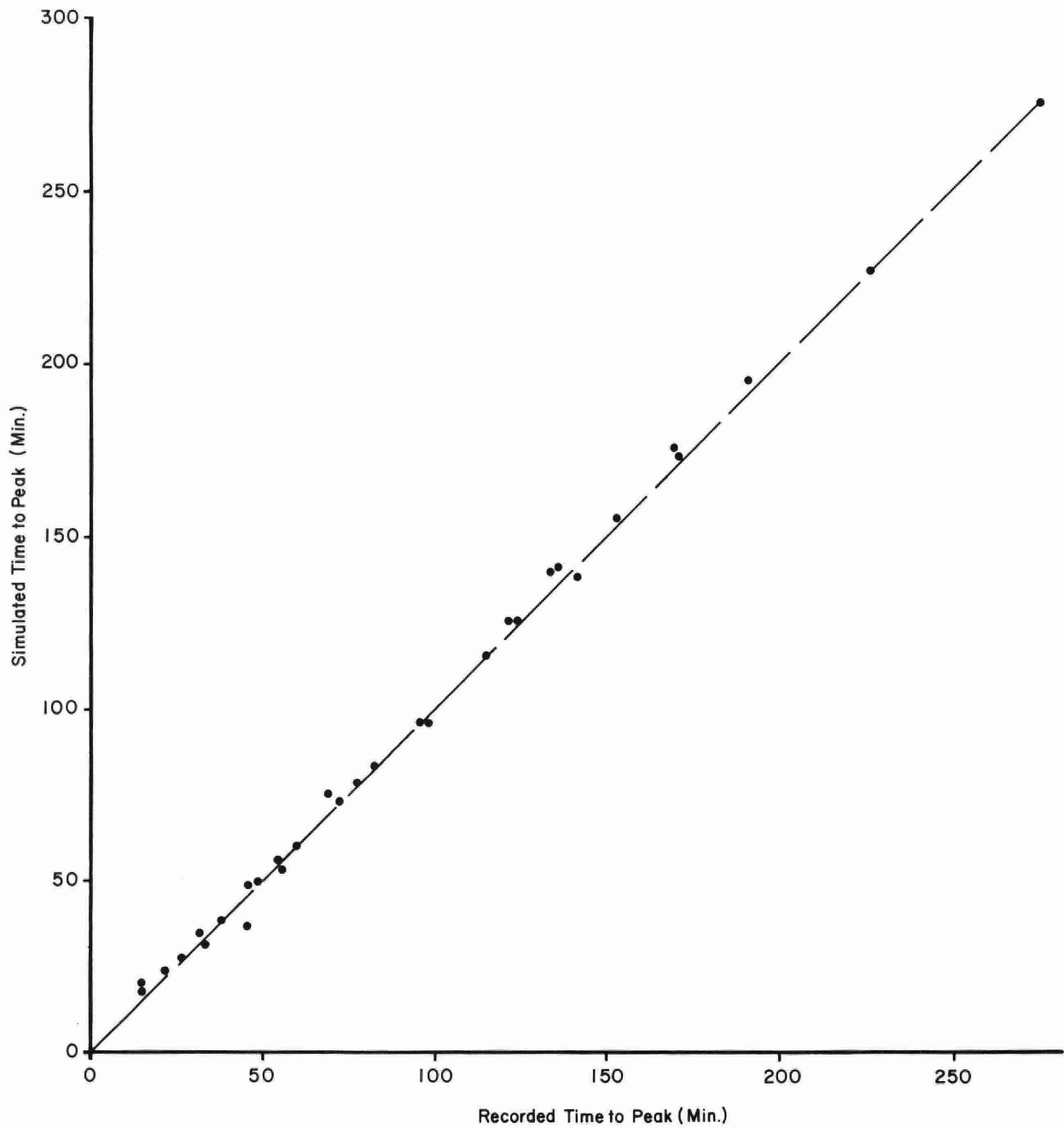


FIGURE 18. SWMM VERIFICATION RESULTS SIMULATED VS RECORDED TIME TO PEAK

flow and 13% of the simulated peak is estimated DWF (see Figure VIIIa). Should the DWF have been estimated, say, 10% too high, the total volume of simulated flow would be about 4% too high and the simulated peak about 1% too high.

4.4.2 Quality verification

The simulated pollutographs of the verification runs are compared to the recorded pollutographs in Figures I to XVIII. As previously described, the automatic sampler was set to activate when the flow reached 15 cfs, and to take samples at 6-minute 40-second intervals. The former setting was selected to avoid the sampling of insignificant storm events, while the latter setting was chosen to get a reasonable time span of recorded data. This meant, however, that the first sample was not taken until 6 minutes 40 seconds after the flow reached 15 cfs, thereby missing the initial part of the recorded pollutograph. This, together with the limited time span of recorded data, makes it difficult, in some cases, to assess whether the discrepancies between a simulated and recorded pollutograph are due to the quantities only, the time shift only, or a combination of both.

An examination of the SS verification runs revealed the following:

- i) The best fit was achieved for the storm on April 22, 1976.
- ii) For most storms, the simulated values were consistently higher than the recorded values.
- iii) About half the runs confirmed the trend noticed during the calibration process, i.e., that a reasonable or good fit could be achieved if simulated values were reduced by about 40% to 50%.
- iv) A good fit could be achieved for the storms on July 20 and August 13 with a time shift of 15 and 10 minutes, respectively.
- v) The storm on March 27, 1976, had exceptionally high recorded initial values. This was most probably because the streets had not been cleaned during the winter months preceeding this storm.

An examination of the BOD verification runs revealed the following:

- i) A reasonable fit was obtained for the storms on April 24, July 2, July 20, and July 29, 1976, especially during the later stages of each storm.
- ii) During the initial stages of the majority of storms, the recorded concentration declined very much more rapidly and at a later time than the simulated concentration.
- iii) The simulated values were generally lower in the initial stages of the storm and higher in the later stages of the storm.

The results gave no indication that a good fit for SS would produce a good fit for BOD and vice versa.

It was concluded that the results of the verification runs could in all likelihood be improved, but only with an extensive recalibration program beyond the financial resources of this study.

- i) The selected urban catchment area is representative of an older residential area served by a combined sewer system and is therefore well suited for combined sewer urban runoff studies.
- ii) In setting up the data acquisition system for the selected study area, it became apparent that the selection of, and the method of operating, a data acquisition system is very site-specific.
- iii) The data acquisition system as described in this report performed well for the first $1\frac{1}{2}$ years after the inevitable teething troubles had been sorted out. In the later stages of the study period, however, wear and tear caused some equipment failure resulting in a few sizeable gaps in the recorded data.
- iv) A substantial amount of collected data on temperature, precipitation and dry and wet weather flow has not been presented in this report. It is, however, available from the Ministry of the Environment (Water Modelling Section of the Water Resources Branch) and would be extremely useful for further studies such as calibration and verification attempts on the CANSWMM snowmelt routine.
- v) The quantity verification results are most encouraging. The simulated flow volumes of the rainfall events were underestimated by about 3% on average, 32 simulated peaks were overestimated by about 2% on average and 32 simulated times to peak were overestimated by about 3% on average. Unfortunately, in most of the monitored rainfall-runoff events the rainfalls were of relatively low intensity. As a result, virtually all the recorded runoff originated from the impervious areas and consequently the Storm Water Management Model could only be verified for this condition. Although this is a major shortcoming, the good verification results obtained in this study do indicate that the SWMM can be a fairly accurate tool for predicting the quantity of runoff from an urban catchment area providing that it is first calibrated. There is also every reason to assume that the same encouraging verification results can be obtained for higher intensity storms with proper calibration. This assumption is reinforced by the reasonable results obtained in attempts to

calibrate input parameters related to pervious areas for the three storms with fairly high rainfall intensities.

- vi) The quality verification results can be considered as reasonable. They could most likely be improved by carrying out an intensive recalibration process with particular emphasis placed upon the method of computing suspended solids and/or the adjustment of the dust and dirt loading rates and pollutant composition. It was concluded that when simulating the quality of runoff for real storm events, from catchment areas in which the streets are swept frequently and/or at irregular intervals, special consideration must be given to the method by which the model computes the dust and dirt accumulation.
- vii) On the whole, the verification results can be rated as very good when they are compared with those of similar studies. It is concluded that this can be attributed to one or a combination of the following factors:
 - a. a well-defined catchment area and the fairly accurate determination of the basic physical characteristics;
 - b. a fairly detailed division scheme for the catchment area and sewer network;
 - c. the good quality and the completeness of the recorded data.

Of the above factors, the good quality of the recorded data was probably the most influential in achieving the encouraging verification results. This is because the sensitivity of the Storm Water Management Model demands that the recording instruments have a time resolution of about one to two minutes, and that the various recording components be accurately synchronized. These criteria were met in this study.

- viii) It is important to note that throughout this study, a time step of five minutes was used for the hyetographs. Because the Storm Water Management Model is extremely sensitive, it is felt that a change in the time step to say, two minutes, could substantially change the simulation results. Consequently, it can only be said that in this particular study, the Storm Water Management Model has been calibrated and verified for hyetographs discretized in five-minute time steps.

ACKNOWLEDGEMENT

Grateful acknowledgement is made of the generous assistance and cooperation received from Environment Canada, the Ontario Ministry of the Environment and the Borough of East York. Special appreciation is extended to Mr. D.G. Weatherbe, the Scientific Liaison Officer, Water Resources Branch, Ontario Ministry of the Environment, Mr. Z. Novak, Water Resources Branch, Ontario Ministry of Environment, Mr. J. Marsalek, Hydraulics Research Division, Canada Centre for Inland Waters, Dr. J. Hipfner, Air Quality Section, Ontario Ministry of the Environment, Mr. W.G. Mills, Mr. O.A. Ringer and Mr. H.J. Bratten, Directors of Engineering Borough of East York and Mr. J. Matthews, Director of Operations, Borough of East York.

APPENDIX A
MONTHLY SUMMARIES OF TEMPERATURE AND PRECIPITATION

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF NOVEMBER 1975

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	12	9	0.22	0.01	0.02	0.03	
2	15	9	0.09	0.01	0.02	0.03	
3	19	12	0.15	0.01	0.02	0.03	
4	17	13	0.12	0.01	0.02	0.04	
5	17	9					
6	16	9					
7	17	11	0.04	0.01	0.01	0.01	
8	20	12	0.02	0.01	0.01	0.02	
9	14	9					
10	16	9	0.63	0.02	0.05	0.08	
11	14	5					
12	16	5					
13	16	-1					
14	1	-2					
15	9	-1					
16	11	6					
17	16	3					
18	13	9					
19	11	2					
20	11	2	0.07	0.01	0.01	0.01	
21	9	3	0.05	0.01	0.01	0.01	
22	4	0					
23	2	0					
24	3	0					
25	2	-1					
26	3	-3	0.02	0.01	0.01	0.01	
27	6	1	0.31	0.01	0.01	0.02	
28	5	0	0.01				
29	7	1	0.03	0.01	0.01	0.01	
30	12	5	0.17	0.01	0.02	0.03	

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF DECEMBER 1975

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	5	-3					
2	-1	-4					
3	-2	-8					
4	0	-7					
5	13	-2					
6	13	-6					0.38
7	Malfunction						
8	Malfunction						
9	3	-1					1.18
10	3	0					0.06
11	2	-2					
12	1	-8					
13	6	-5	0.01				
14	15	6	0.01				
15	14	-1	0.30	0.01	0.03	0.04	
16	Malfunction						
17	Malfunction						0.09
18	-7	-12					
19	-7	-18					
20	-5	-15					
21	-11	-18					
22	-2	-15					
23	-2	-14					
24	-4	-16					
25	2	-5					
26	-1	-5					
27	-4	-7					0.04
28	0	-9					
29	Malfunction						
30	5	1					0.40
31	3	0					

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF JANUARY 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	0	-7					0.02
2	3	-8					0.02
3	3	-5					
4	-5	-12					
5	-5	-14					
6	3	-8					
7	3	-14					0.11
8	-8	-17					
9	-8	-13					
10	-5	-12					
11	-3	-9					
12	Malfunction						
13	3	-1					
14	0	-7					0.22
15	-5	-10					0.04
16	1	-13					0.11
17	-13	-21					
18	-13	-25					
19	1	-13					
20	2	-2					
21	-5	-10					
22	-10	-25					
23	-14	-26					
24	-14	-17					
25	0	-14					0.01
26	7	0					0.55
27	1	-4					
28	-1	-9					
29	0	-8					0.02
30	-8	-13					
31	-2	-15					

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF FEBRUARY 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	0	-15					
2	-11	-24					
3	-4	-13					
4	-1	-7					
5	-6	-9					
6	-5	-10					
7	-3	-13					
8	-1	-6					
9	-1	-9					
10	8	-2					
11	7	-4					
12	6	-5					
13	7	-3					
14	0	-4					
15	10	0					0.26
16	7	1					0.22
17	3	0					0.05
18	7	1					0.46
19	6	2					
20	5	1					
21	3	1					0.90
22	2	-11					0.07
23	-1	-16					
24	8	-1					
25	14	4					
26	11	5					0.12
27	9	3					
28	5	-1					
29	12	0					0.07

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF MARCH 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1							
2	-5	-7					
3	0	-7					
4	1	0					0.23
5	11	0					1.39
6	0	-2					
7	1	-5					
8	-2	-7					
9	0	-7					
10	2	-1					0.13
11	-1	-6					
12	5	-6	0.46	0.02	0.05	0.07	
13	5	-5	0.10	0.01	0.03	0.03	
14	3	-5	0.01				
15	2	-5					
16	-1	-5					0.07
17	5	-12					
18	0	-10					
19	15	0					0.14
20	18	7					
21	15	-9					0.03
22	-1	-10					
23	12	-2					
24	18	4					
25	17	4	0.07	0.01	0.01	0.02	
26	9	2					
27	15	3	0.19	0.02	0.05	0.06	
28	11	1					
29	6	0					
30	17	5					
31	17	6	0.98	0.01	0.02	0.04	

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF APRIL 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	10	3	0.04	0.01	0.01	0.01	
2	10	2					
3	15	2					
4	11	2					
5	15	1					
6	17	4					
7	13	0					
8	10	-1					
9	10	-2					
10	20	3					
11	9	-2					
12	9	-4					
13	20	2					
14	21	5					
15	22	9	0.80	0.07	0.16	0.26	
16	24	13	0.18	0.01	0.04	0.06	
17	29	16					
18	29	14					
19	29	14					
20	21	11					
21	14	10	0.09	0.01	0.02	0.02	
22	16	11	0.12	0.01	0.02	0.03	
23	14	5					
24	8	6					0.13
25	6	0					1.15
26	7	0					0.19
27	8	1					
28	17	5					
29	19	5					
30	18	3					

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF MAY 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	16	9					
2	18	10	0.23	0.01	0.02	0.04	
3	10	2					
4	14	2					
5	24	7					
6	20	4	0.97	0.01	0.02	0.03	
7	4	2	0.56	0.01	0.02	0.03	
8	15	3					
9	20	7	0.03	0.01	0.01	0.02	
10	22	7					
11	13	6	0.27	0.01	0.03	0.05	
12	15	5					
13	19	6					
14	20	8					
15	22	10					
16	22	11	0.35	0.02	0.05	0.07	
17	21	8	0.07	0.01	0.01	0.02	
18	12	4					
19	11	3	0.11	0.03	0.03	0.03	
20	26	9					
21	20	10					
22	18	7					
23	20	6					
24	malfunction						
25	18	13					
26	malfunction						
27	malfunction						
28	23	16					
29	25	15					
30	20	13					
31	18	12	0.67	0.02	0.08	0.14	

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF JUNE 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	17	10	0.12	0.01	0.02	0.04	
2	21	13					
3	26	9					
4	23	12					
5	27	18					
6	32	15	0.09	0.01	0.04	0.04	
7	35	15					
8	35	19					
9	31	21					
10	32	19					
11	31	19					
12	19	13					
13	22	13	0.56	0.06	0.24	0.39	
14	30	19					
15	30	20					
16	24	18	0.28	0.04	0.13	0.15	
17	19	14					
18	21	13					
19	23	16	0.27	0.01	0.01	0.02	
20	23	14	0.01				
21	21	17					
22	26	19	0.02	0.01	0.01	0.01	
23	26	20					
24	24	19	0.12	0.01	0.01	0.02	
25	27	19	0.80	0.02	0.07	0.13	
26	29	17	0.44	0.05	0.14	0.14	
27	27	18					
28	26	17	0.12	0.01	0.02	0.03	
29	24	17	0.01				
30	20	17	0.35	0.01	0.03	0.06	

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF JULY 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	22	16	0.45	0.06	0.17	0.22	
2	20	15	0.17	0.01	0.02	0.03	
3	19	15	0.14	0.01	0.03	0.05	
4	24	15					
5	31	18					
6	30	19					
7	24	18	0.23	0.01	0.04	0.06	
8	25	17	0.02	0.01	0.01	0.02	
9	25	14					
10	22	17	0.09	0.01	0.01	0.01	
11	32	19	0.13	0.01	0.02	0.03	
12	22	14	0.02	0.01	0.02		
13	22	17					
14	24	15	0.02	0.01	0.01	0.01	
15	24	14					
16	26	15	0.12	0.01	0.03	0.04	
17	24	13	0.04	0.02	0.04		
18	27	15					
19	28	20					
20	24	18	0.57	0.02	0.04	0.08	
21	25	19	0.04	0.01	0.03	0.03	
22	22	18					
23	25	16	0.02	0.01	0.01	0.01	
24	23	15					
25	22	12					
26	29	14					
27	31	22					
28	23	17					
29	20	16	0.71	0.02	0.07	0.10	
30	23	17					
31	21	17	1.09	0.06	0.19	0.35	

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF AUGUST 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	23	14					
2	20	14					
3	25	12					
4	26	17					
5	26	19					
6	21	14					
7	21	14	0.15	0.01	0.01	0.02	
8	17	15	0.16	0.01	0.01	0.02	
9	21	17					
10	28	15					
11	27	20					
12	27	21	0.27	0.02	0.05	0.06	
13	25	19	0.31	0.08	0.19	0.21	
14	23	18	0.03	0.01	0.01	0.02	
15	22	15					
16	24	13					
17	29	15					
18	26	18					
19	27	15					
20	30	16					
21	30	21					
22	31	20					
23	29	20					
24	23	15					
25	26	13					
26	26	18					
27	28	20	0.11	0.04	0.06	0.06	
28	29	20	0.97	0.07	0.19	0.37	
29	21	13					
30	17	9					
31	23	7					

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF SEPTEMBER 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	21	13	0.28	0.02	0.07	0.11	
2	17	9					
3	23	8					
4	28	17	0.16	0.03	0.09	0.10	
5	18	12					
6	21	8					
7	30						
8	25	17					
9	25	17					
10	17	11	0.53	0.03	0.08	0.13	
11	17	11	0.01				
12	31	10					
13	27	15					
14	27	15					
15	25	17					
16	21	18					
17			0.56	0.03	0.08	0.13	
18			0.34	0.02	0.07	0.11	
19							
20			0.18	0.01	0.02	0.03	
21			0.22	0.01	0.03	0.04	
22			0.05	0.01	0.03	0.05	
23			0.21	0.01	0.03	0.05	
24							
25							
26			0.22	0.01	0.01	0.02	
27			0.01				
28							
29							
30							

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF OCTOBER 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1			0.01				
2							
3							
4							
5							
6							
7			0.45	0.01	0.03	0.04	
8							
9	9	2	0.39	0.01	0.02	0.03	
10	11	6					
11	12	2					
12	16	3					
13	21	3					
14	11	5	0.03	0.01	0.01	0.02	
15	19	7					
16	8	5					
17	6	1					
18	6	-1					
19	5	2	0.15	0.01	0.01	0.01	
20	9	3	0.29	0.01	0.01	0.02	
21	9	3	0.04	0.01	0.01	0.01	
22	7	2	0.11	0.01	0.01	0.02	
23	8	2	0.05	0.01	0.02	0.03	
24	6	4	0.19	0.01	0.01	0.01	
25	4	1	0.04	0.01	0.01	0.01	
26	4	-2					
27	3	-4					
28	7	-1					
29	11	2					
30	11	6					
31	7	2	0.09	0.01	0.01	0.01	

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF NOVEMBER 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	7	-1					
2	9	-2					
3	10	4					
4	9	2	0.02	0.01	0.01	0.01	
5	5	2					
6	7	3					
7	6	-2					
8	-2	-6					
9	-1	-6	0.02	0.01	0.01	0.01	
10	2		0.01				
11	2	-4					
12	4	-4					
13	6	0					
14	5	1					
15	6	-2					
16	9	-3					
17	8	2					
18	8	3	0.01				
19	8	3	0.02	0.01	0.01	0.01	
20	3	-3					
21	0	-6					
22	3	-2	0.01				
23	3	-5					
24	1	-3					
25	5	-2	0.05	0.01	0.01	0.01	
26	11	5	0.24	0.01	0.02	0.03	
27	15	8	0.17	0.01	0.04	0.04	
28	5	-4					
29	Malfunction						
30	Malfunction						

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF DECEMBER 1976

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	-4	-15					
2	-6	-17					
3	-4	-8					
4	-2	-6					0.01
5	Malfunction						0.04
6	Malfunction						0.05
7	2	-15					0.37
8	-8	-18					0.01
9	-3	-15					
10	5	-3					0.02
11	0	-6					
12	0	-7					
13	-7	-18					
14	6	-11					
15	6	0					
16	2	0					0.01
17	3	-1					0.08
18	0	-5					
19	6	-4					
20	Malfunction		0.43	0.01	0.02	0.04	
21	-10	-14					
22	-2	-11					
23	-2	-6					
24	-2	-9					
25	2	-3					
26	-3	-10					
27	-2	-16					
28	-8	-11					
29	-6	-14					
30	-10	-16					
31	-10	-15					

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF JANUARY 1977

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	-5	-13					
2	-4	-5					
3	-3	-5					
4	-1	-5					
5	-1	-9					0.04
6	-3	-10					
7	-4	-11					
8	-7	-14					0.14
9	-9	-20					
10	-9	-16					
11	-8	-16					
12	-8	-15					
13	-8	-16					
14	-5	-8					0.01
15	-5	-10					
16	-13	-18					
17	-13	-22					0.02
18	-11	-24					
19	-4	-11					
20	-3	-7					
21	-4	-12					
22	-11	-16					
23	-5	-14					
24	-3	-5					0.01
25	0	-6					
26	-2	-7					
27	-5	-15					
28	-5	-16					
29	-14	-20					0.01
30	Malfunction						
31	Malfunction						

The Data Acquisition System was shut down February, March and April, 1977.

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF MAY 1977

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1							
2			0.03	0.01	0.01	0.01	
3							
4			0.01	0.01	0.01	0.01	
5			0.02	0.01	0.01	0.01	
6							
7							
8							
9							
10	16	5					
11	20	9					
12	23	9					
13	20	14	0.01	0.01	0.01	0.01	
14	19	7	0.01	0.01	0.01	0.01	
15	18	7					
16	24	9					
17	32	16					
18	28	19	0.13	0.01	0.02	0.03	
19	27	15					
20	27	18	0.02	0.01	0.01	0.02	
21	30	16					
22	27	17					
23	27	18	0.02	0.01	0.02	0.02	
24	25	15	0.07	0.01	0.02	0.03	
25	25	17					
26	21	14					
27	28	13					
28	32	10	0.01	0.01	0.01	0.01	
29	15	9					
30	21	10					
31	21	11	0.33	0.02	0.06	0.09	

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF JUNE 1977

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	22	14	0.24	0.02	0.05	0.07	
2	16	8	0.17	0.01	0.02	0.04	
3	18	5					
4	24	10	0.06	0.01	0.03	0.04	
5	23	15					
6	17	11	0.16	0.01	0.01	0.02	
7	14	9					
8	20	7					
9	20	8					
10	20	11					
11	25	13					
12	20	15					
13	22	12					
14	26	17					
15	23	16					
16	24	17					
17			0.38	0.02	0.08	0.13	
18			0.90	0.04	0.15	0.22	
19							
20			0.07	0.01	0.02	0.02	
21	24	14					
22	24	13					
23	24	14					
24	24	14					
25	24	17	0.75	0.07	0.26	0.32	
26	28	16					
27	28	17					
28	26	19					
29	23	16	0.98	0.07	0.22	0.32	
30	24	14	0.10	0.02	0.06	0.07	

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF JULY 1977

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	25	18					
2	22	15					
3	24	12					
4	29	18					
5	28	22					
6	24	14	1.57	0.07	0.24	0.44	
7	18	15	0.41	0.02	0.06	0.08	
8	26	18	0.08	0.01	0.01	0.01	
9	28	17					
10	22	16					
11	23	15					
12	28	20	0.12	0.01	0.02	0.03	
13	30	20					
14	26	17					
15	31	20	0.48	0.06	0.23	0.35	
16	31	21					
17	30	23					
18	31	21					
19	29	23	0.02	0.01	0.01	0.01	
20	37	23					
21	28	22					
22	25	15					
23	29	18					
24	26	18	0.02	0.01	0.01	0.01	
25	25	17					
26	22	15					
27	22	12					
28	23	14					
29	25	18	0.23	0.02	0.06	0.11	
30	26	19					
31	27	17	1.19	0.10	0.42	0.77	

SUMMARY OF DAILY TEMPERATURE AND PRECIPITATION FOR
MONTH OF AUGUST 1977

Date	TEMPERATURE °C		PRECIPITATION (INCHES)				
	Maximum	Minimum	Total Rain	Maximum Rain For 1 Minute	Maximum Rain For 5 Minutes	Maximum Rain For 10 Minutes	Rain and/or Melting Snow
1	25	18	0.06	0.02	0.05	0.06	
2	28	15					
3	26	19	0.06	0.02	0.06	0.06	
4	30	21	0.02	0.01	0.01	0.02	
5	29	20	0.91	0.09	0.32	0.48	
6	26	21	0.47	0.03	0.12	0.17	
7	24	20	0.08	0.01	0.04	0.05	
8	24	21	0.33	0.01	0.04	0.06	
9	24	16					
10	26	17	1.18	0.06	0.24	0.33	
11	28	18	0.08	0.01	0.02	0.03	
12	24	15					
13	26	17					
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

APPENDIX B

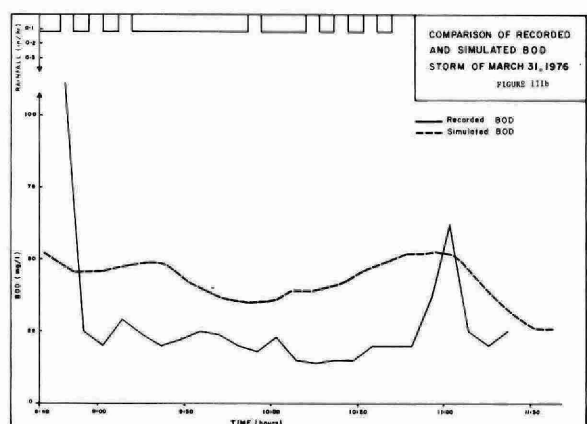
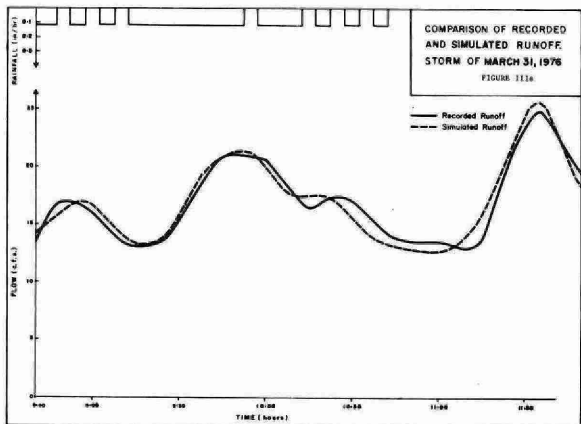
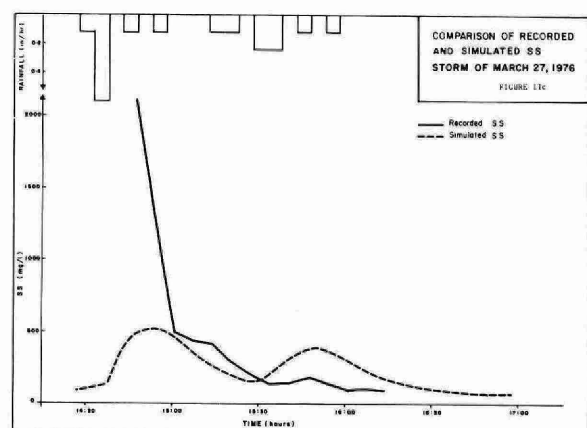
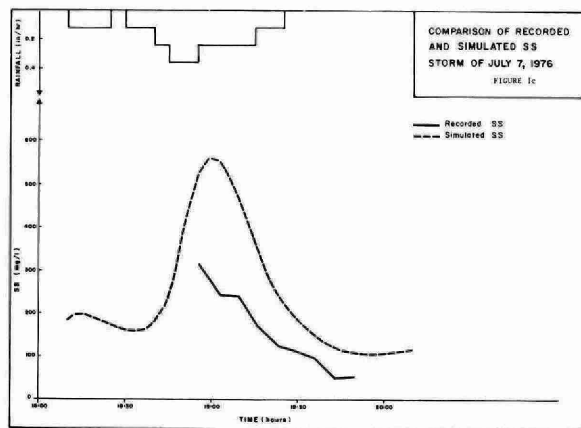
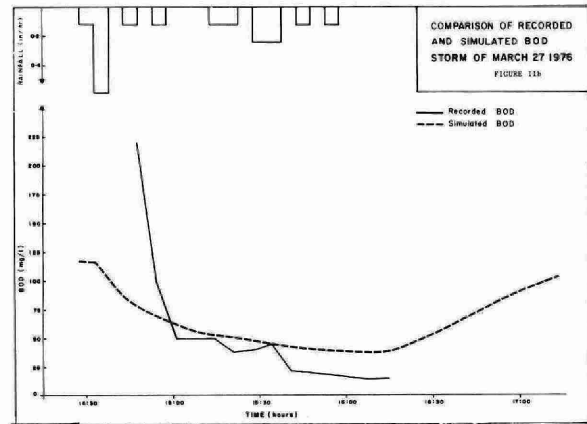
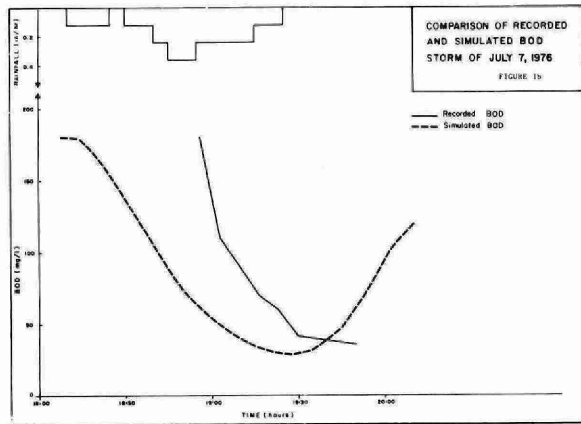
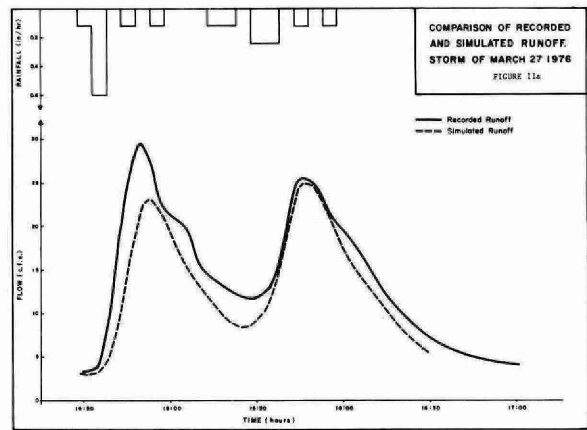
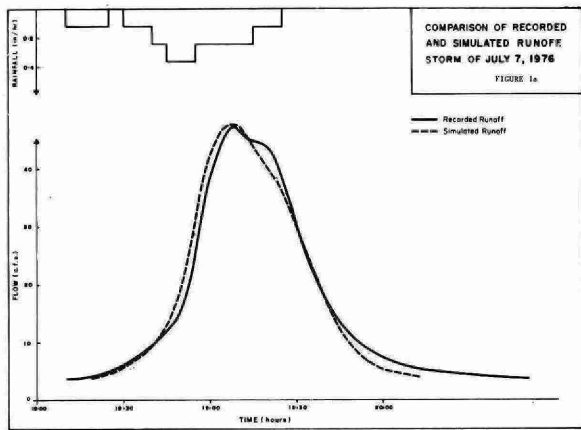
RAINFALL DATA FOR STORMS WITH COMPLETE SET OF MONITORED DATA

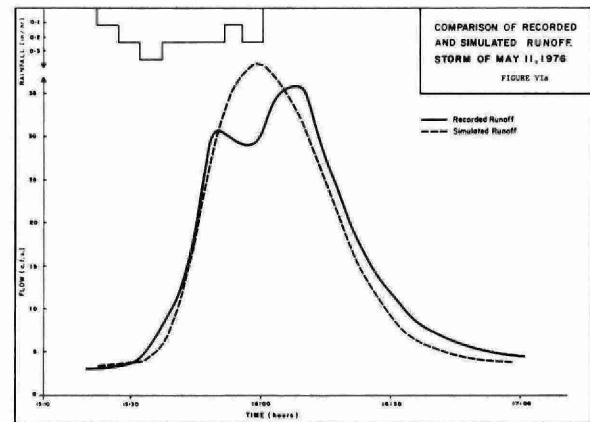
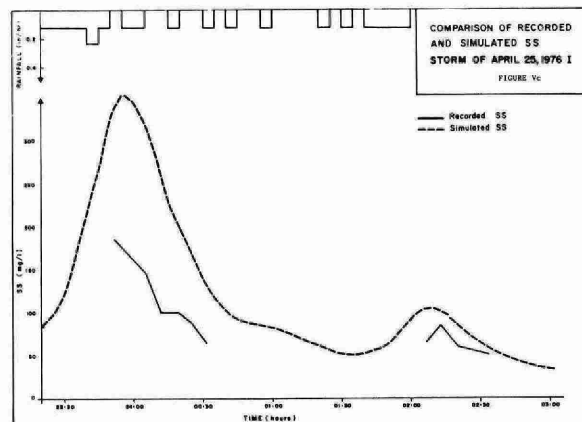
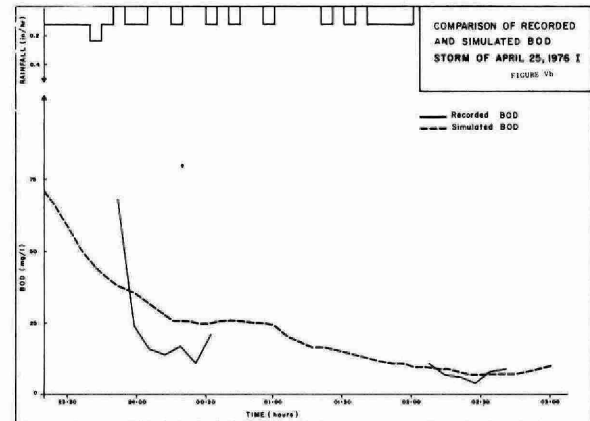
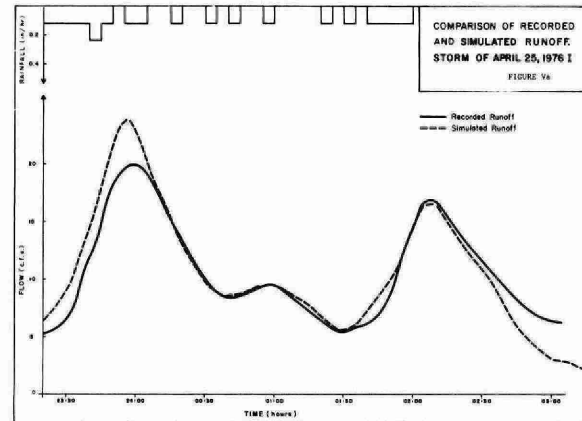
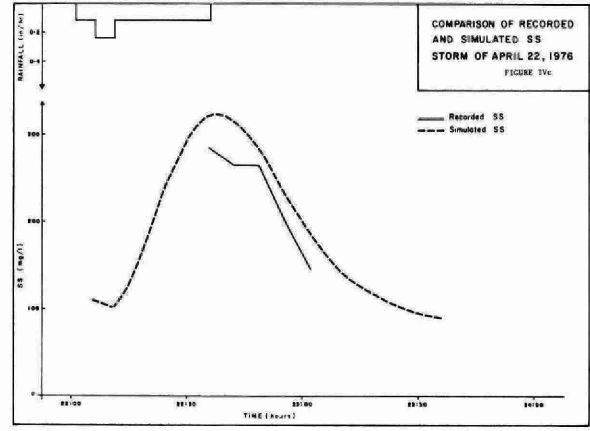
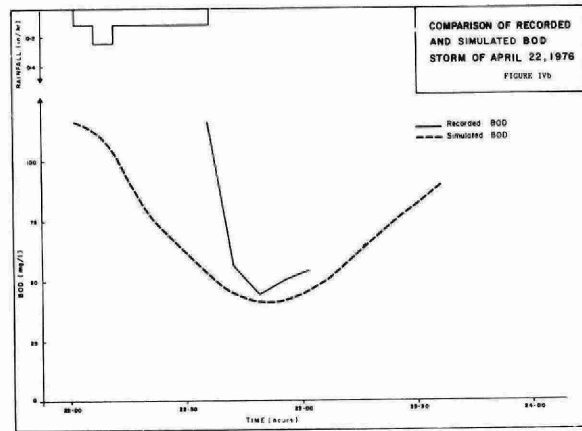
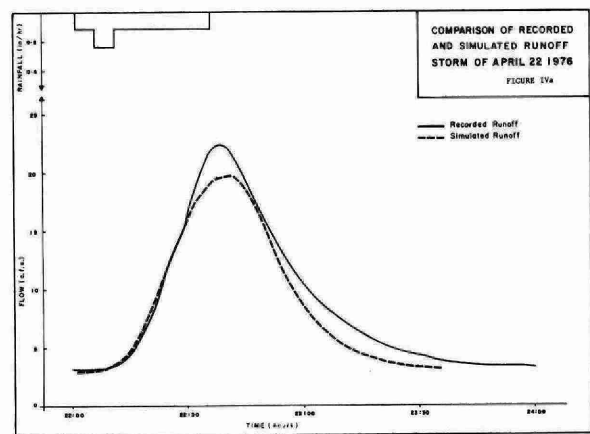
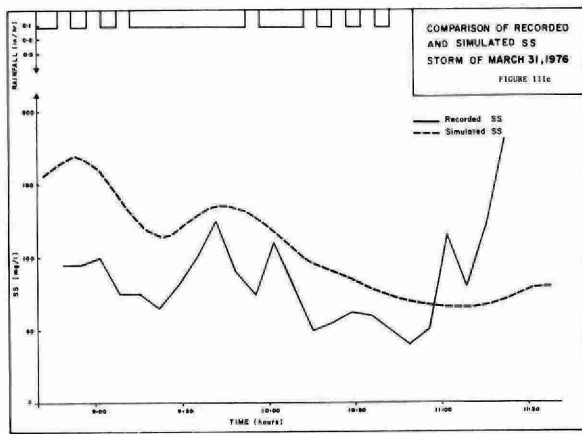
TIMES OF 0.01" OF RAINFALL AS RECORDED BY THE PRINTOUT RECORDER IN HOURS AND MINUTES

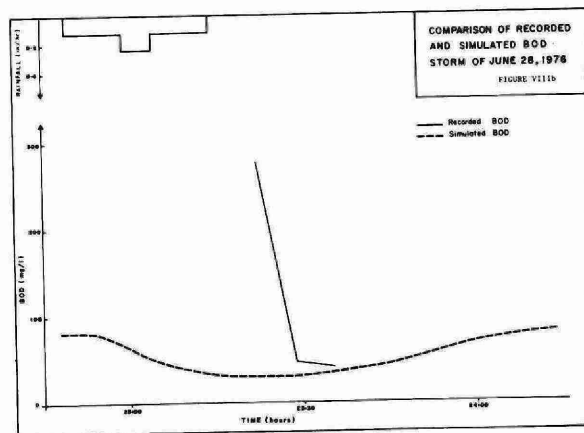
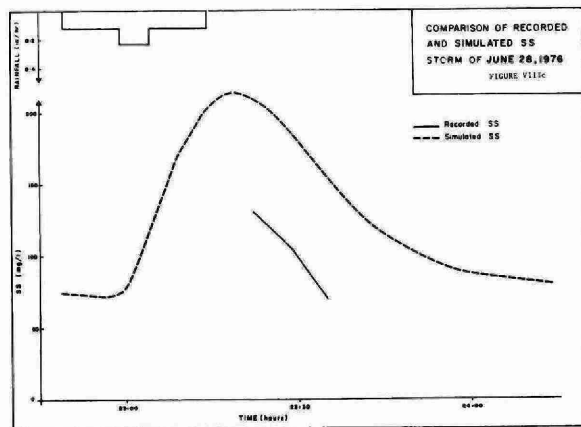
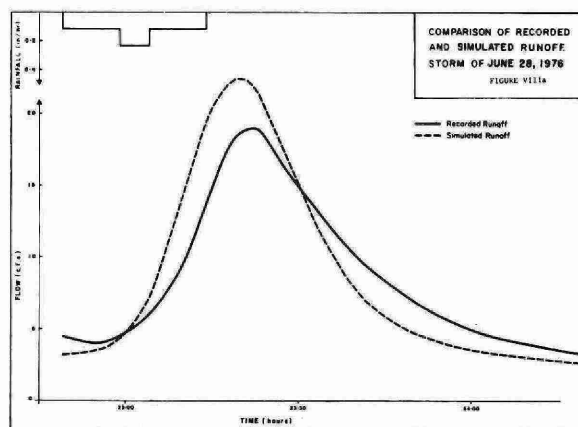
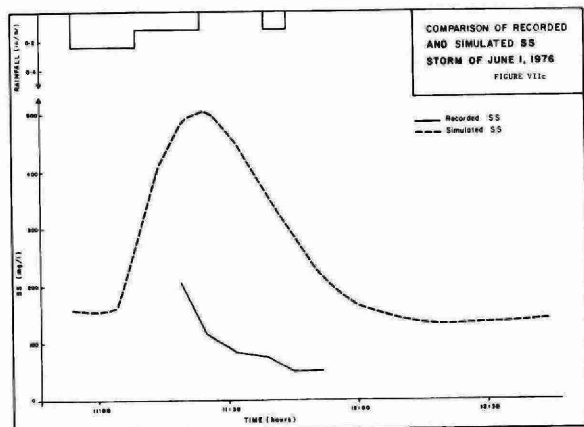
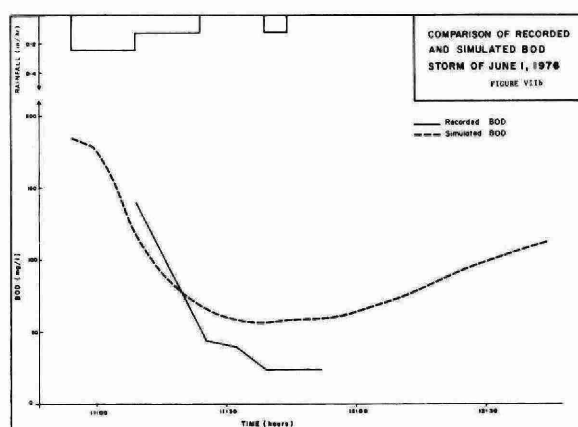
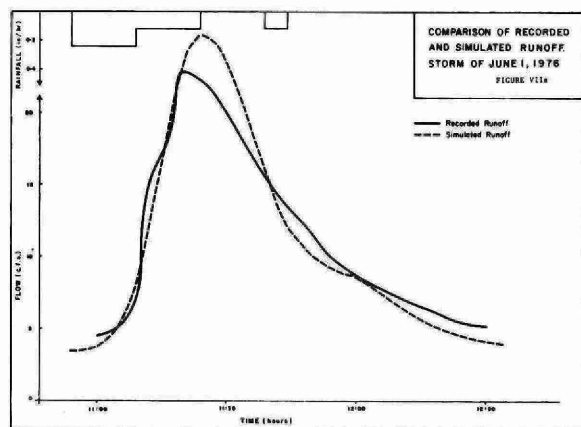
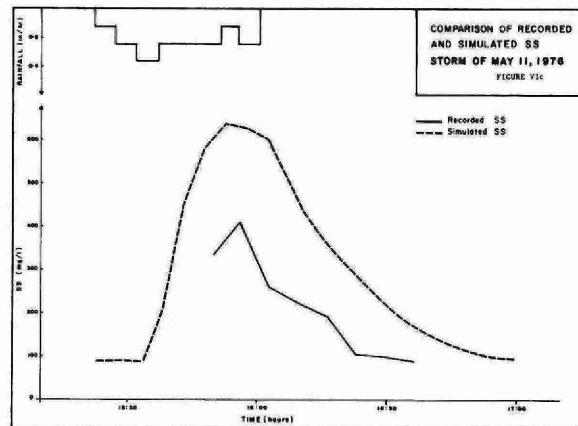
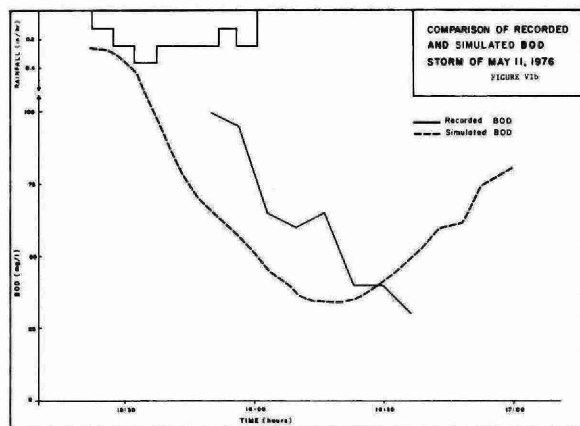
27/03/76	31/03/76 (cont'd)	22/04/76 (cont'd)	06/05/76 (cont'd)	01/06/76	01/07/76	07/07/76	20/07/76 (cont'd)
14:29	11:38	22:15	09:43	10:54	7:53	18:11	19:28
14:33	11:44	22:20	09:49	10:56	8:04	18:17	19:31
14:34	11:51	22:23	09:55	11:00	8:07	18:24	19:37
14:34	11:58	22:26	10:02	11:03	8:10	18:32	19:41
14:35	12:05	22:32	10:16	11:06	8:13	18:37	19:45
14:36	12:11		10:28	11:08	8:17	18:42	20:04
14:44	12:28	24-	10:34	11:12	8:20	18:44	20:44
14:57	12:33	25/04/76	10:41	11:15	8:23	18:46	20:50
15:13	12:38		10:50	11:23	8:25	18:48	20:52
15:24	12:45	22:22	11:08	11:39	8:28	18:49	20:54
15:29	12:53	22:36			8:31	18:50	20:56
15:31	13:06	22:58	11:41	28/06/76	8:33	18:52	20:57
15:34	13:17	23:15	12:06		8:36	18:54	20:58
15:37	13:22	23:24	12:29	22:50	8:39	18:56	21:00
15:47	13:25	23:28	12:37	22:55	8:41	18:58	21:02
15:54	13:27	23:32	12:43	23:00	8:47	19:00	21:02
	13:30	23:36	12:52	23:06		19:02	21:04
31/03/76	13:33	23:41	13:00	23:08	16:58	19:06	21:05
	13:36	23:45	13:08	23:13	16:58	19:08	21:07
06:37	13:39	23:50	13:13		16:58	19:10	21:09
06:50	13:42	23:56	13:22	30/06/76	16:58	19:12	21:11
07:01	13:48	00:04	13:38		16:59	19:15	21:13
07:07	13:54	00:20	13:51	6:50	16:59	19:20	21:16
07:12	13:57	00:34	14:02	6:52	16:59		21:18
07:17	14:01	00:42	14:09	6:57	16:59	11/07/76	21:20
07:27	14:06	01:00	14:17	7:07	16:59		21:23
07:55	14:10	01:23	14:27	7:42	16:59	00:30	21:25
08:10	14:15	01:35	14:36	7:47	17:00	00:41	21:27
08:19	14:25	01:44	14:43	8:01	17:00	00:47	21:29
08:26	14:29	01:48	14:52	8:07	17:00	00:50	21:31
08:32	14:33	01:52	15:04	8:11	17:00	00:54	21:33
08:37	14:39	01:58	15:24	8:16	17:01	01:03	21:35
08:44	14:45	02:06	15:42	8:20	17:01	01:09	21:37
08:55	14:49	02:18	15:52	8:25	17:02	01:13	21:38
09:06	14:56	02:36	16:03	8:29	17:03	01:17	21:40
09:13	15:02	02:57	16:15	8:33	17:04	01:23	21:42
09:19	15:08	03:11	16:33	8:35	17:05	01:29	21:44
09:24	15:21	03:21	16:46	8:36	17:05	01:37	21:47
09:28	15:32	03:31	16:58	8:38	17:07		21:50
09:33	15:49	03:44		8:40		16/07/76	21:52
09:38	16:12		11/05/76	8:42	02/07/76		21:54
09:43	16:17	06/05/76		8:45		06:30	21:57
09:49	16:21		15:24	8:48	11:22	07:34	22:01
09:57	16:25	06:44	15:28	8:52	11:28	06:37	22:03
10:05	16:28	07:23	15:30	8:57	11:32	06:39	22:07
10:11	16:31	07:37	15:33	9:02	11:34	06:40	22:16
10:18	16:39	07:44	15:35	9:13	11:39	06:43	22:28
10:30	16:44	08:12	15:37		11:46	06:56	
10:40	17:04	08:24	15:39	10:36	11:52		
10:48	17:26	08:40	15:42	10:53	11:57	20/07/76	
10:59	17:33	08:51	15:44	10:57	11:59		
11:06	17:57	08:58	15:46	11:03	12:02	18:56	
11:09		09:06	15:50	11:07	12:09	19:09	
11:13	22/04/76	09:16	15:52	11:09	12:23	19:16	
11:17		09:24	15:54	11:12		19:20	
11:21	22:01	09:29	15:58	11:23		19:22	
11:24	22:06	09:33	16:01	11:56		19:25	
11:29	22:10	09:38		11:59			

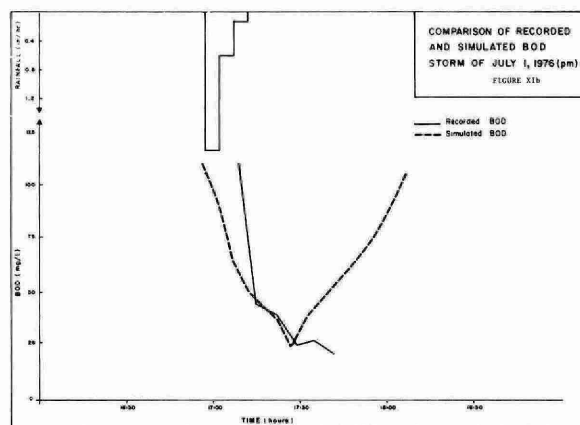
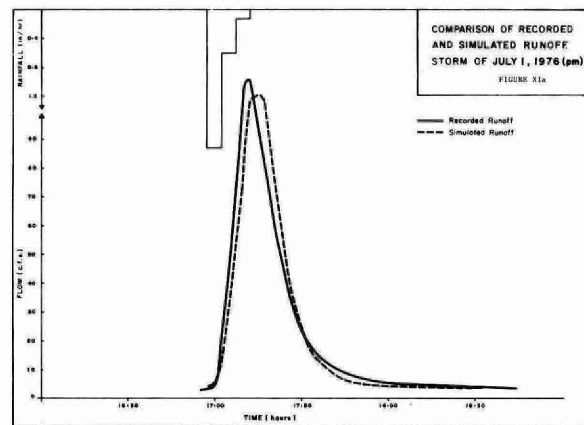
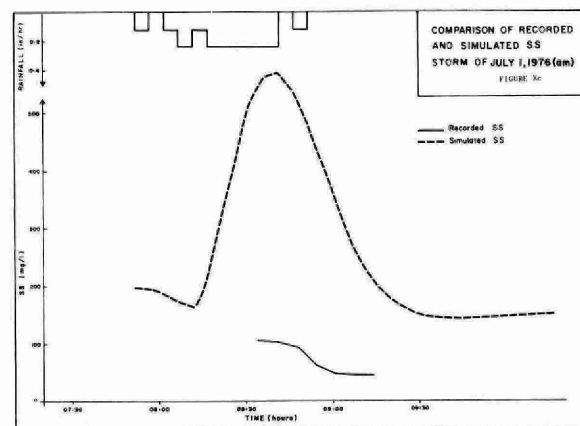
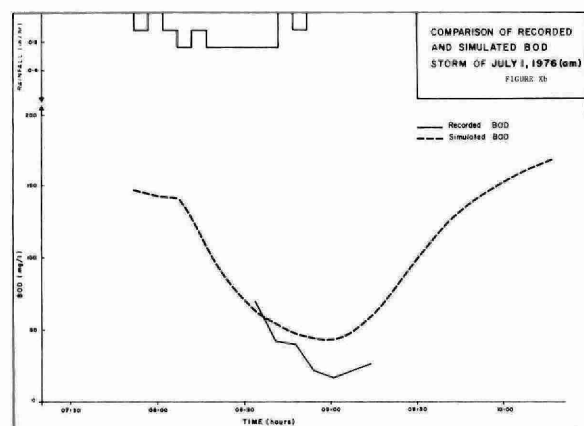
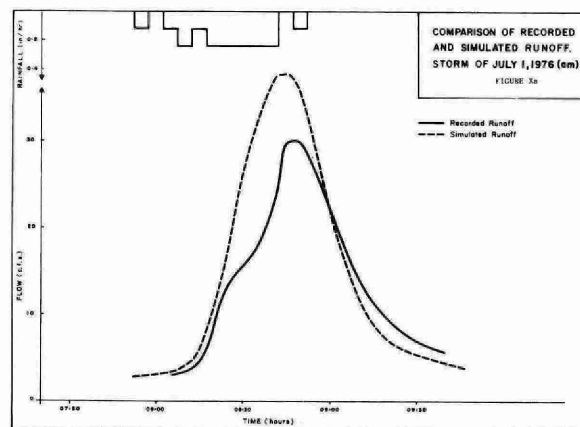
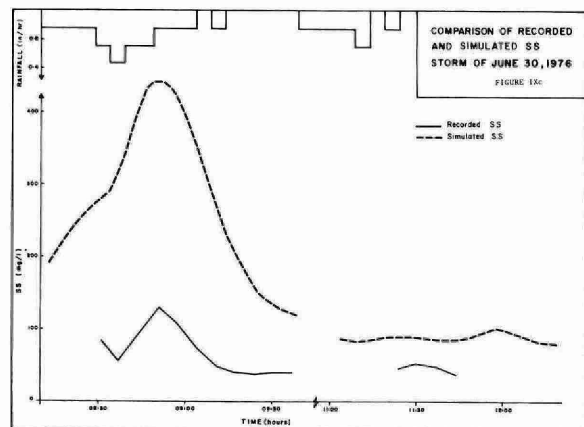
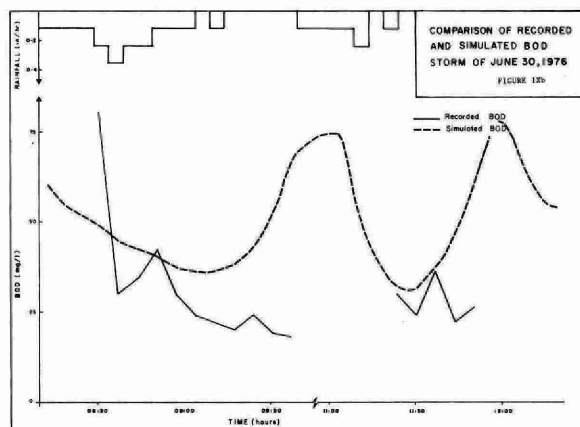
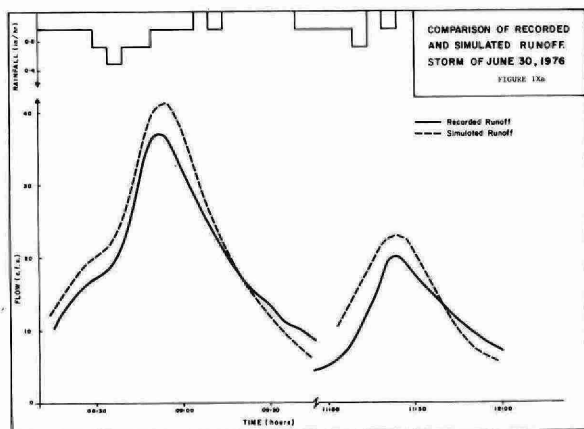
29/07/76	31/07/76 (cont'd)	28/08/76 (cont'd)	28/08/76 (cont'd)	25/06/77 (cont'd)	25/06/77 (cont'd)	23/06/77 (cont'd)	10/08/77 (cont'd)
07:27	09:41	16:13	16:44	04:24	05:21	04:02	18:12
07:34	09:44	16:14	16:44	04:24	05:34	04:04	18:12
07:40	09:47	16:14	16:44	04:25		04:06	18:12
07:44	09:52	16:14	16:45	04:25	29/06/77	04:07	18:13
07:54	10:02	16:14	16:45	04:25		04:08	18:13
08:01	10:09	16:15	16:46	04:25	02:30	04:09	18:13
08:08	10:10	16:15	16:47	04:25	02:30	04:10	18:13
08:13	10:11	16:15	16:47	04:25	02:30	04:10	18:13
08:22	10:11	16:16	16:47	04:26	02:31	04:11	18:14
08:23	10:12	16:16	16:47	04:26	02:31	04:11	18:14
08:25	10:19	16:17	16:48	04:26	02:32	04:12	18:14
08:26	10:20	16:17	16:48	04:26	02:32	04:12	18:15
08:28	10:32	16:18	16:48	04:26	02:33	04:12	18:16
08:29	10:33	16:27	16:48	04:26	02:33	04:13	18:17
08:31	10:34	16:29	16:48	04:26	02:34	04:13	18:17
08:34	10:36	16:30	16:49	04:27	02:35	04:14	18:18
08:49	10:55	16:30	16:49	04:27	02:35	04:14	18:21
08:56	10:59	16:30	16:50	04:27	02:36	04:17	18:30
09:02	11:03	16:31	16:51	04:27	02:36	04:21	18:31
09:06	11:11	16:31	16:52	04:27	02:36	04:22	18:32
09:10	11:13	16:31	16:52	04:27	02:36	04:24	18:33
09:13	11:15	16:31	16:53	04:28	02:37	04:27	18:34
09:16	11:30	16:31	16:53	04:28	02:37	04:30	18:35
09:18	11:30	16:32	16:54	04:28	02:37	04:34	18:36
09:21	11:31	16:32	16:54	04:28	02:37	04:36	18:38
09:24	11:33	16:32	16:57	04:29	02:37	04:38	18:40
09:29		16:32	17:02	04:29	02:38	04:40	
09:34	13/08/76	16:33	17:06	04:30	02:38	04:42	
09:38		16:33	17:47	04:31	02:38	04:43	
09:40	16:11	16:34		04:33	02:38	04:46	
09:41	16:12	16:34	01/09/76	04:35	02:38	04:48	
09:41	16:13	16:35		04:36	02:38	04:52	
09:42	16:13	16:35	00:55	04:37	02:38	04:55	
09:43	16:14	16:35	01:04	04:38	02:39	05:05	
09:44	16:14	16:35	01:17	04:39	02:39	05:08	
09:44	16:14	16:36	01:19	04:40	02:39	05:15	
09:46	16:14	16:36	01:25	04:40	02:39	05:18	
09:47	16:15	16:36	01:26	04:41	02:40	05:22	
09:48	16:15	16:36	01:27	04:41	02:40	05:35	
09:50	16:15	16:36	01:28	04:42	02:41	05:43	
09:52	16:15	16:37	01:29	04:43	02:41		
09:54	16:15	16:37	01:30	04:44	02:42	10/08/77	
09:55	16:15	16:37	01:30	04:45	02:44		
09:59	16:15	16:37	01:31	04:46	02:53	18:08	
10:18	16:15	16:37	01:32	04:48	03:49	18:08	
10:50	16:16	16:38	01:33	04:49	03:54	18:09	
	16:16	16:40	01:33	04:50	03:55	18:09	
31/07/76	16:16	16:41	01:35	04:52	03:55	18:09	
	16:16	16:42	01:57	04:53	03:56	18:09	
08:52	16:17	16:42	01:59	04:56	03:56	18:10	
09:01	16:21	16:42	02:00	04:57	03:56	18:10	
09:03		16:42	02:03	04:59	03:57	18:10	
09:05	28/08/76	16:42	02:05	05:01	03:57	18:10	
09:07		16:43		05:02	03:57	18:10	
09:08	16:07	16:43	25/06/77	05:03	03:57	18:10	
09:08	16:09	16:43		05:04	03:57	18:11	
09:09	16:10	16:43	04:21	05:06	03:57	18:11	
09:11	16:11	16:43	04:22	05:09	03:58	18:11	
09:13	16:12	16:43	04:23	05:11	03:58	18:11	
09:14	16:12	16:43	04:23	05:13	03:59	18:11	
09:17	16:13	16:44	04:24	05:16	04:00	18:12	

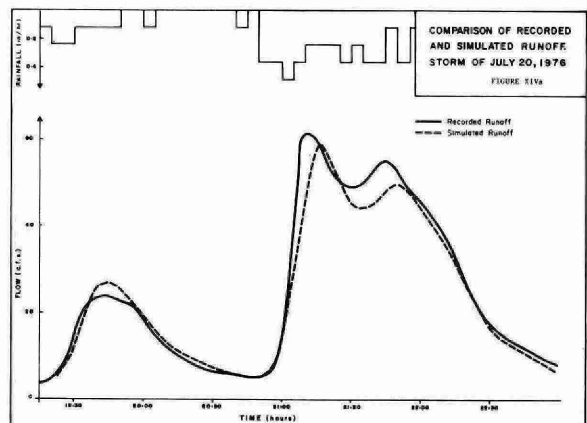
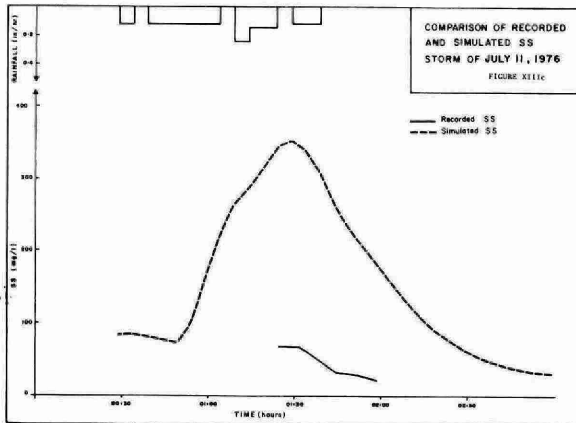
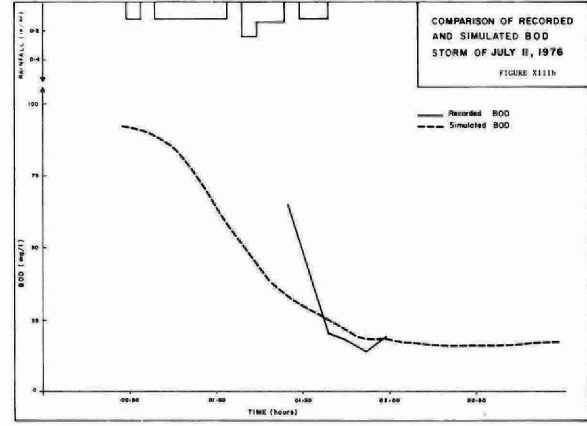
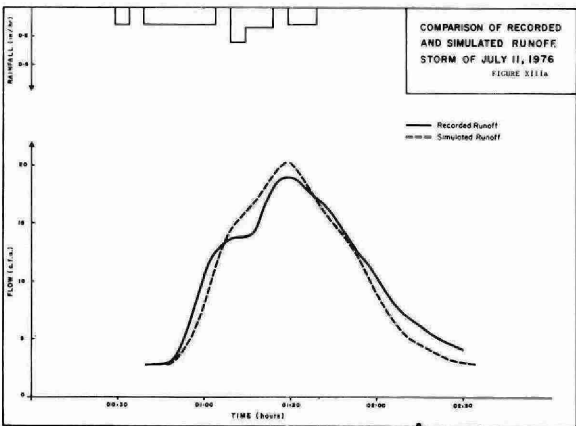
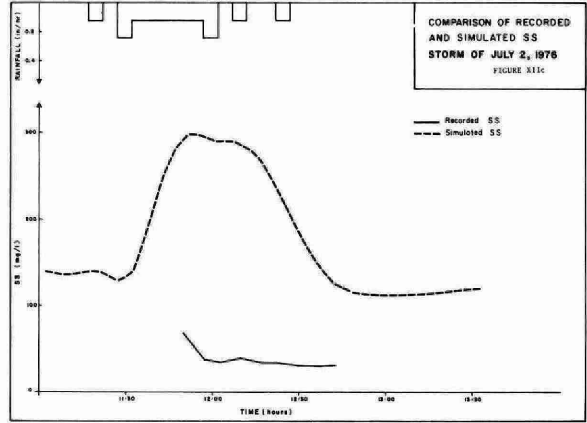
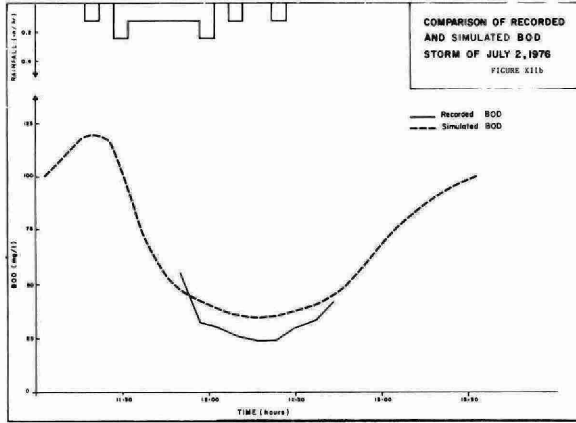
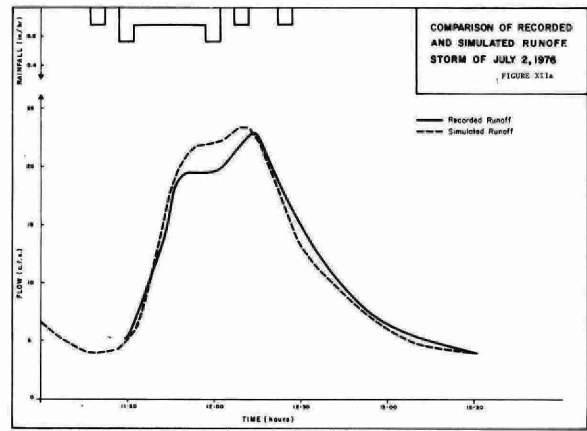
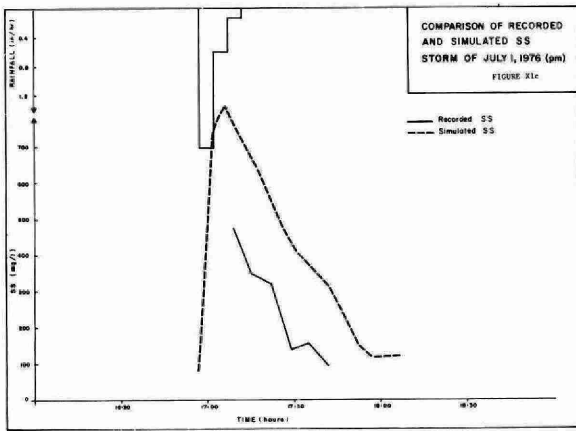
APPENDIX C
HYDROGRAPHS AND POLLUTOGRAPHS

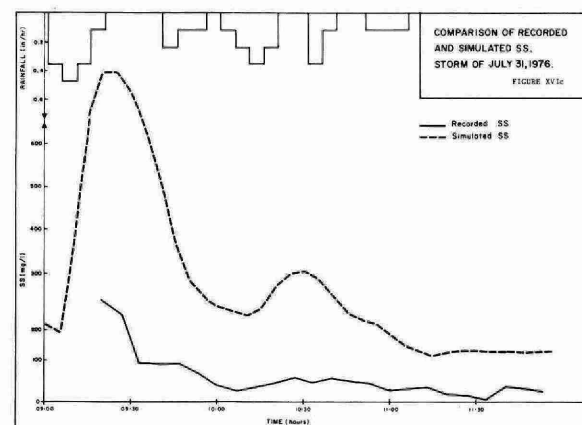
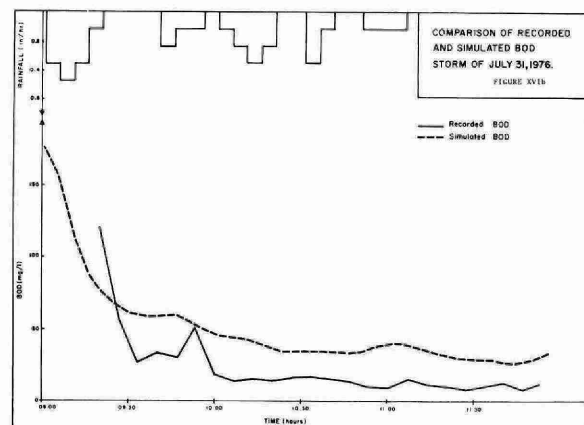
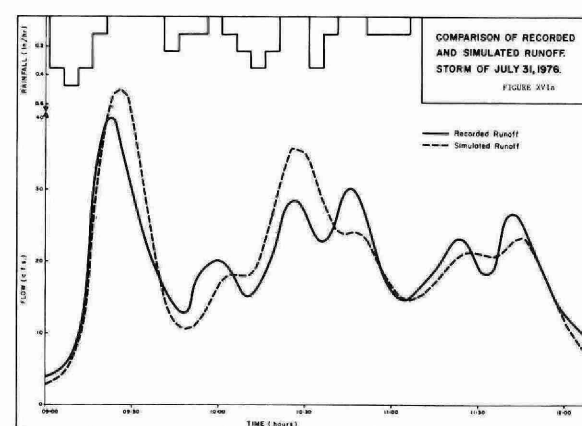
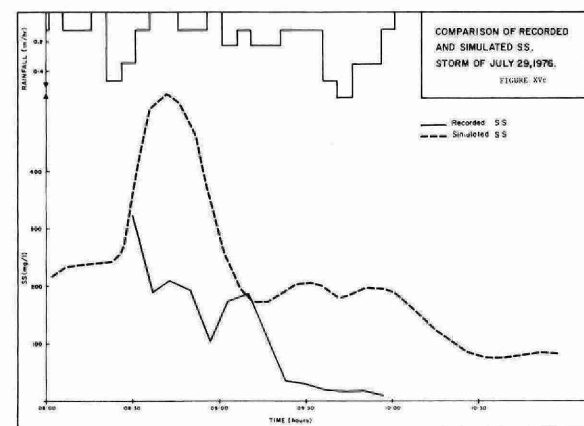
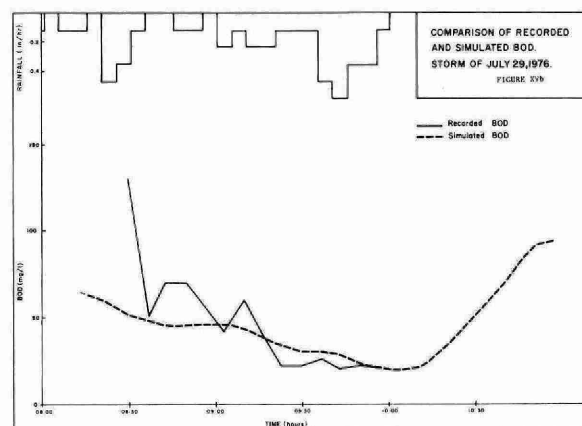
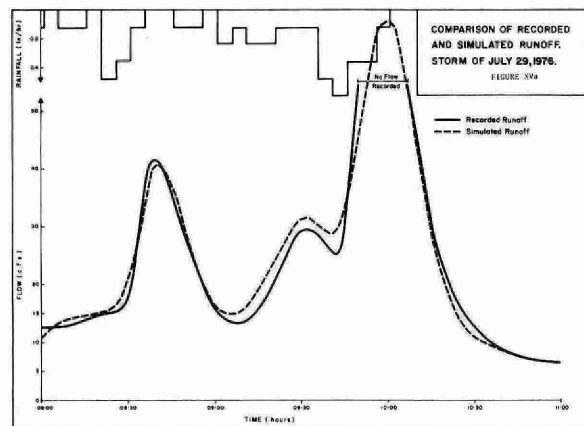
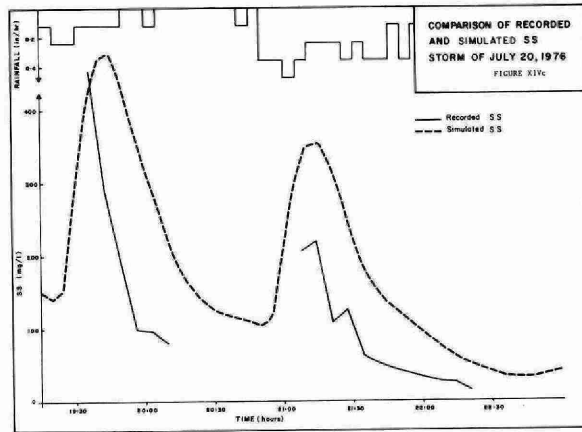
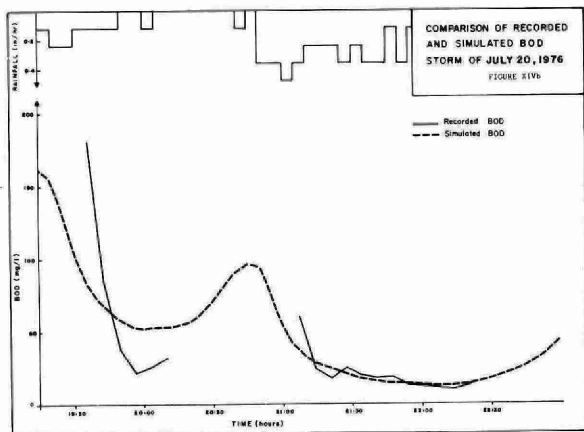


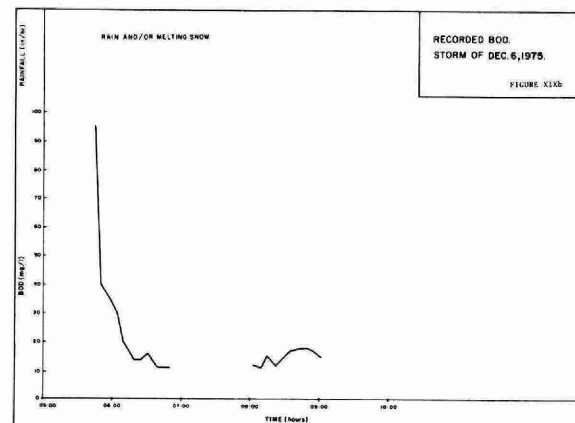
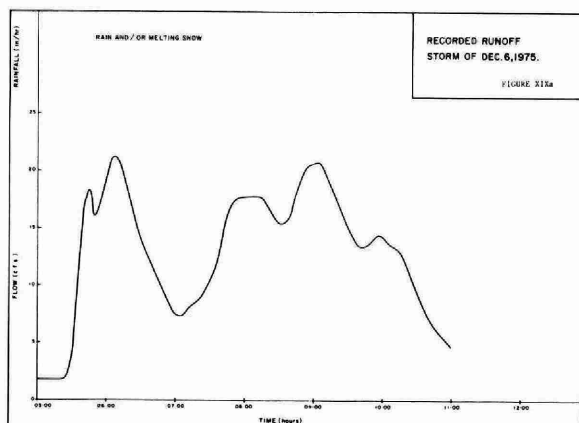
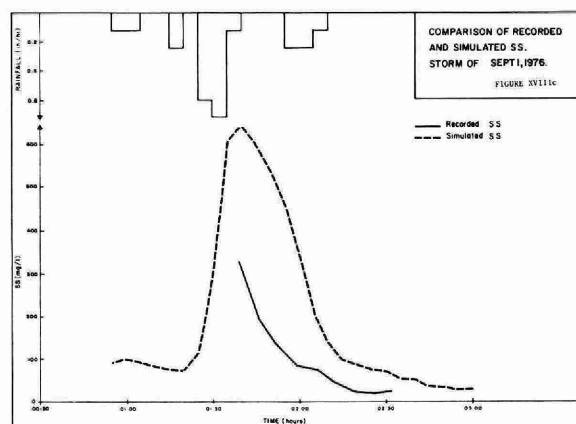
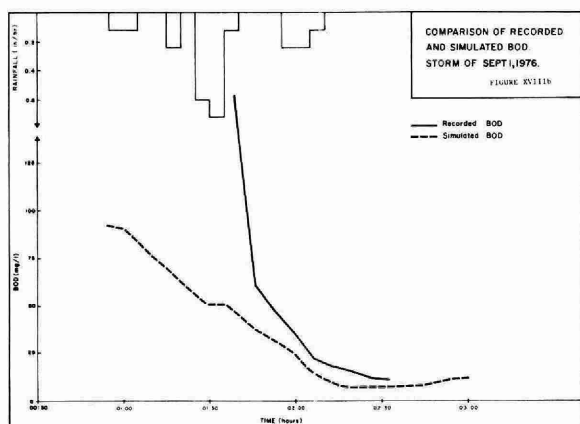
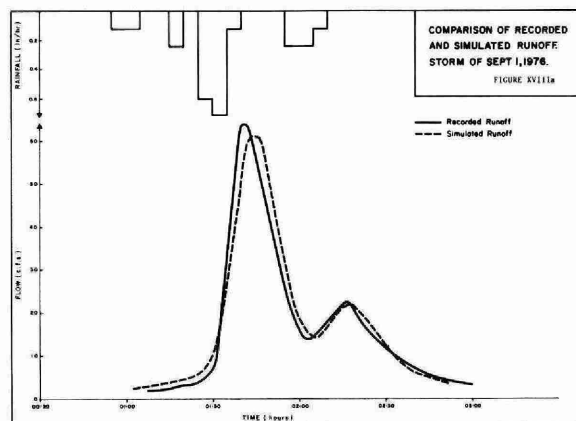
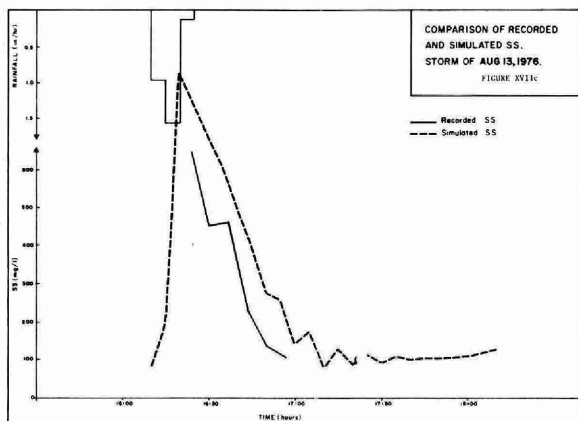
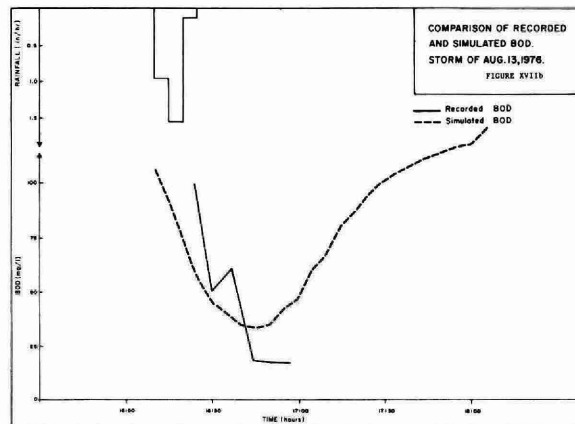
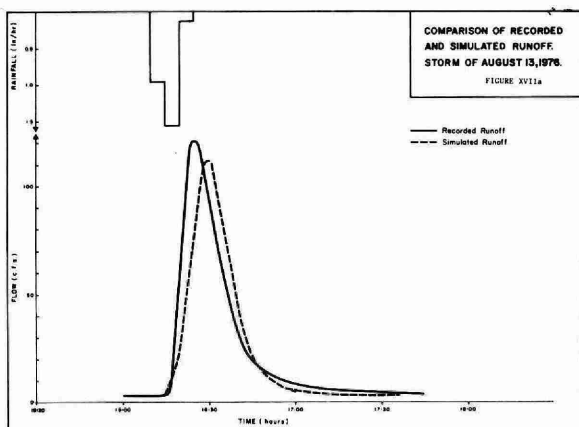


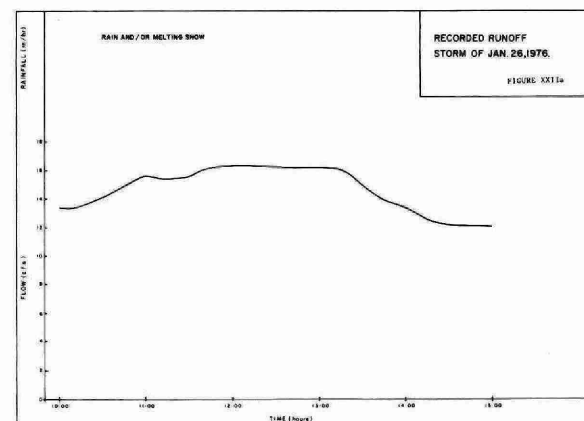
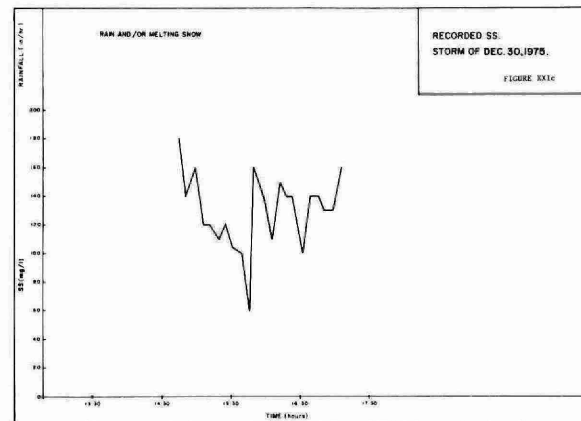
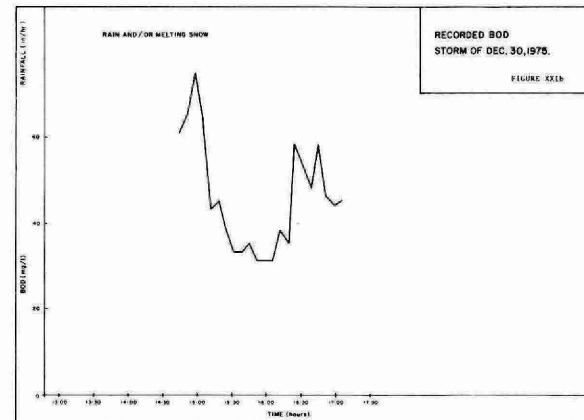
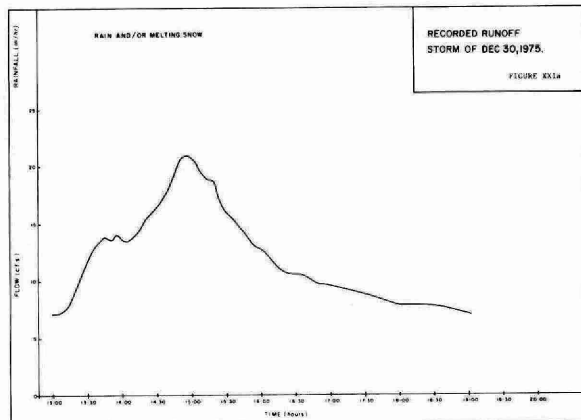
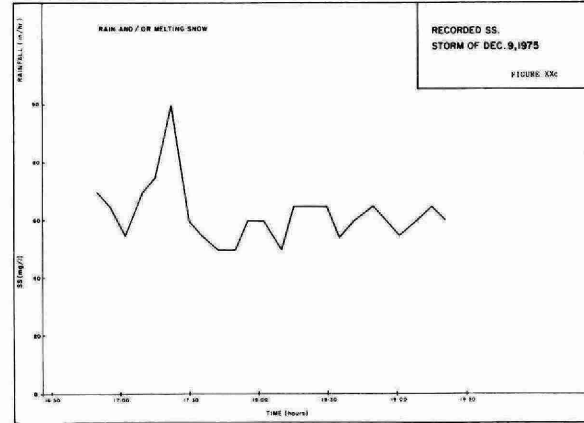
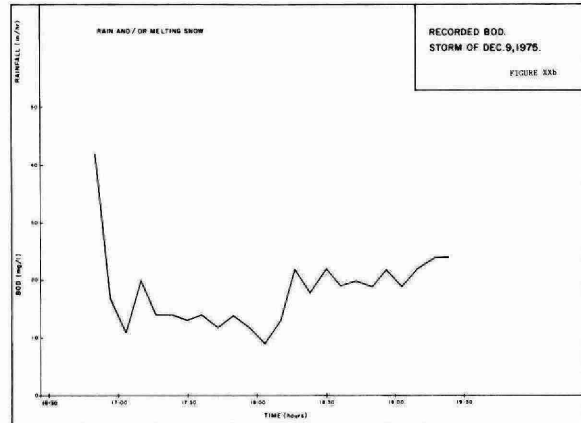
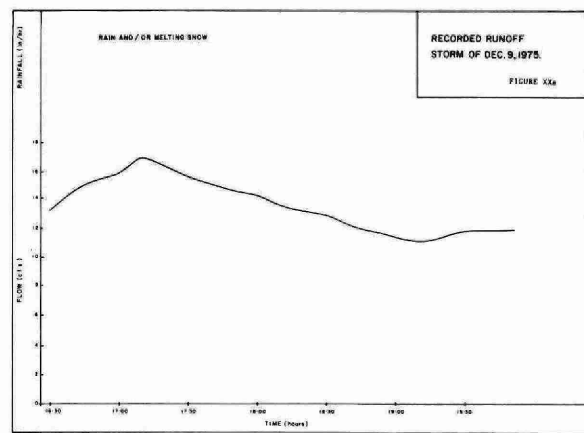
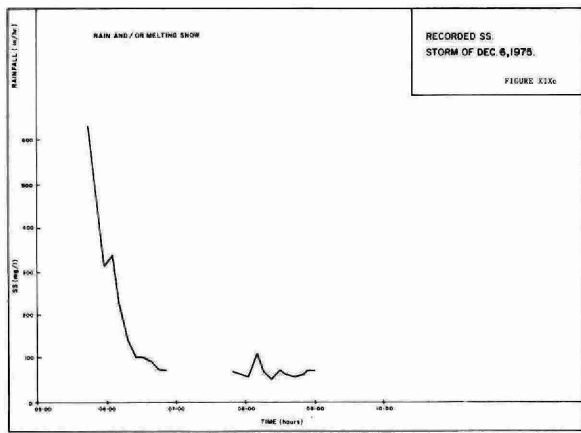


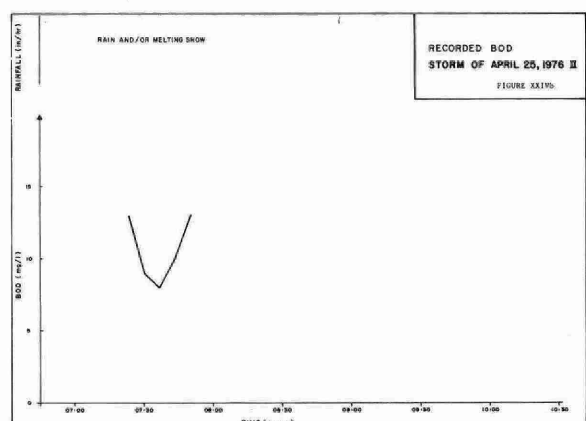
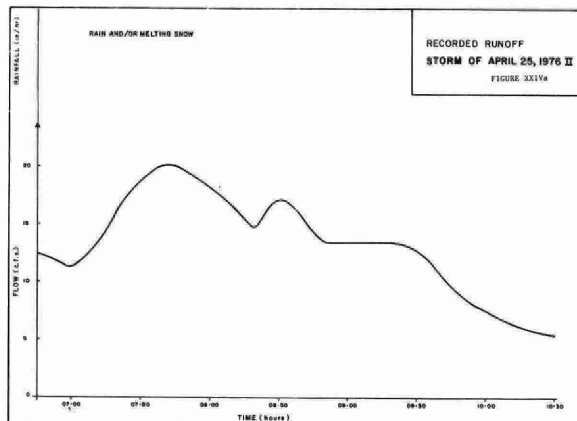
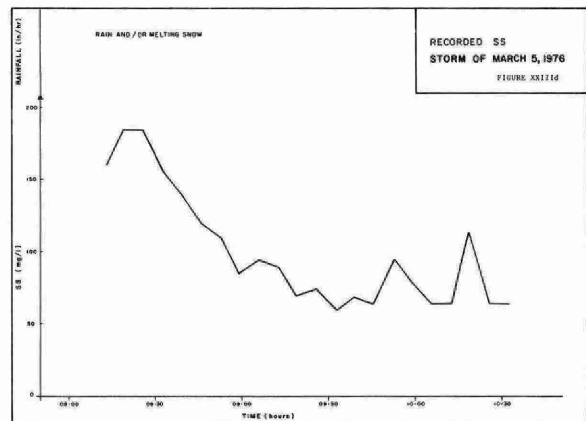
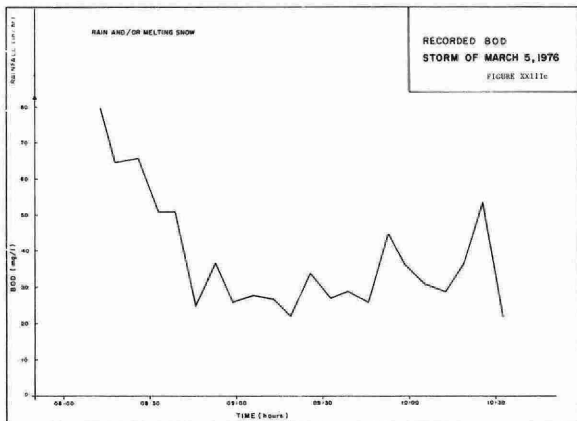
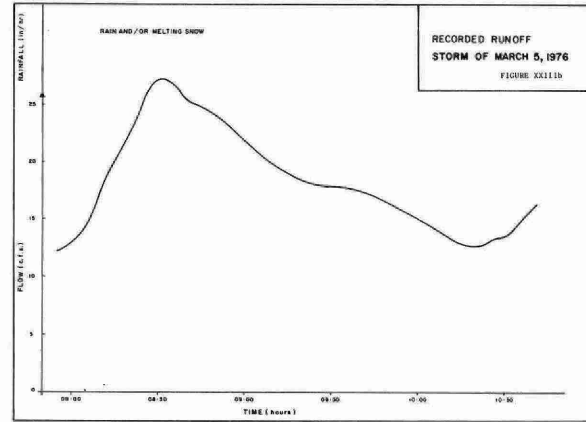
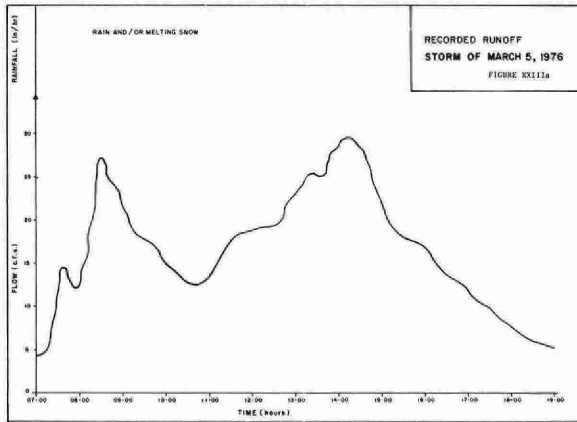
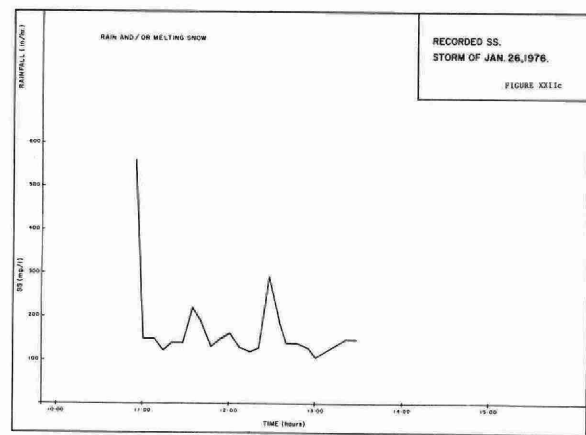
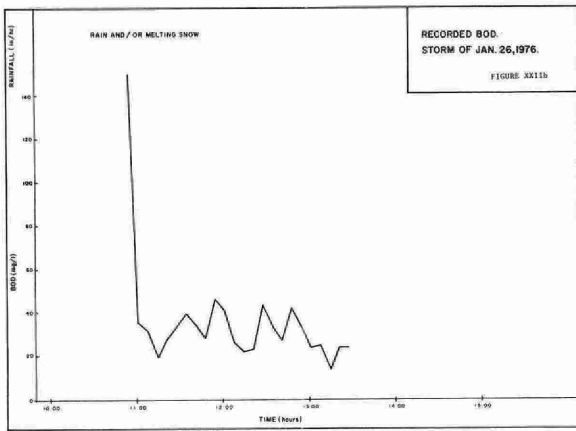


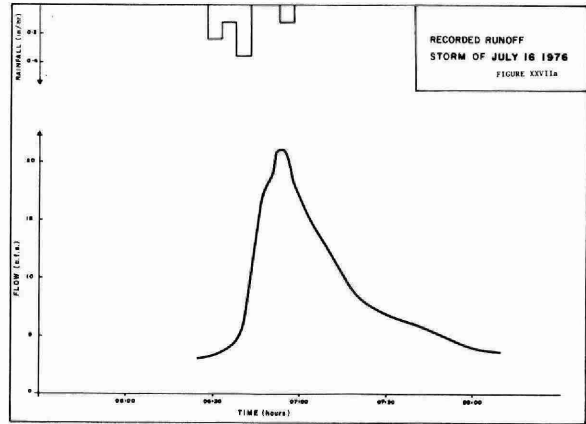
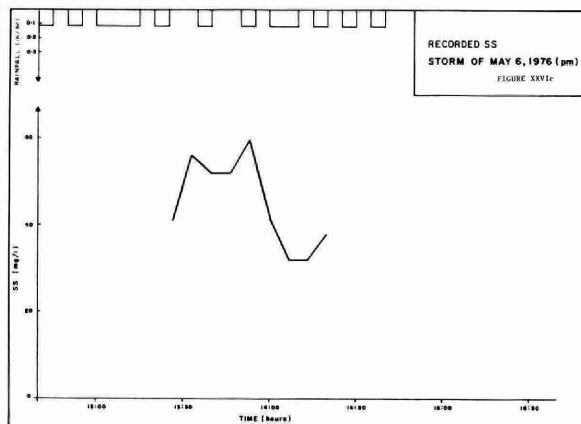
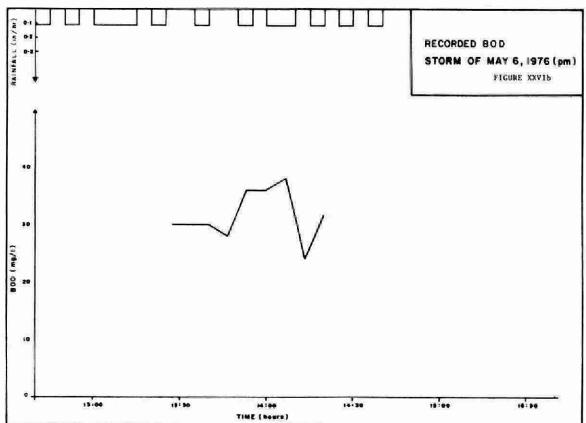
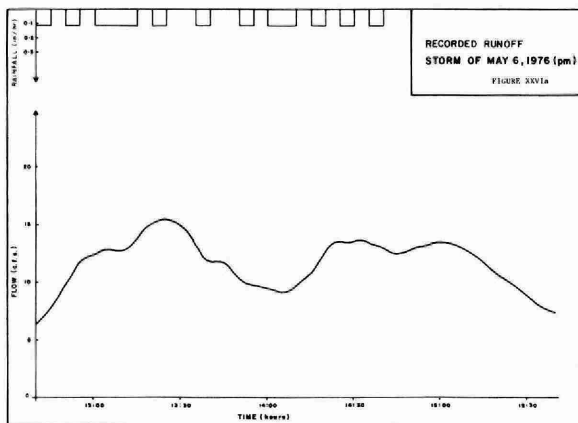
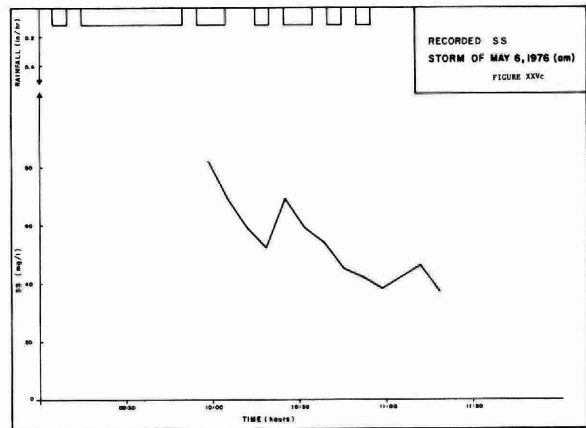
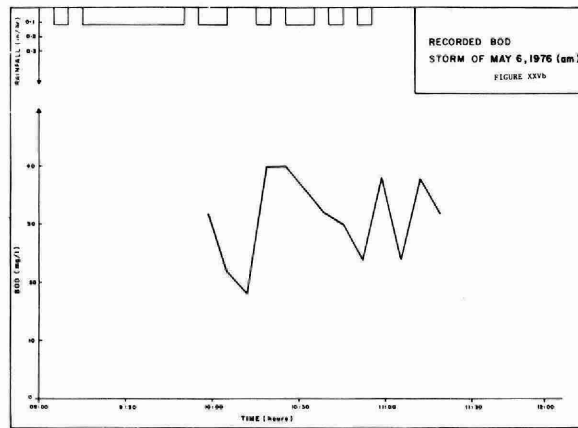
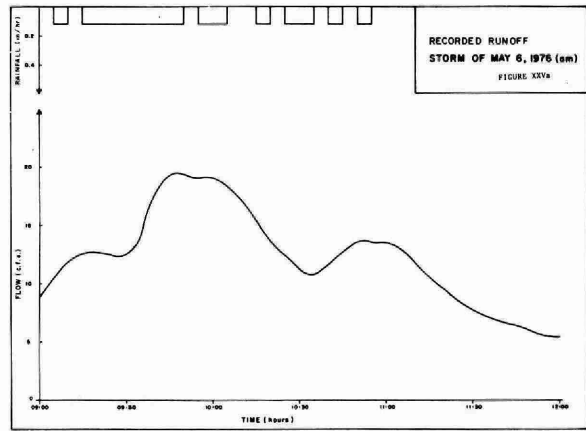
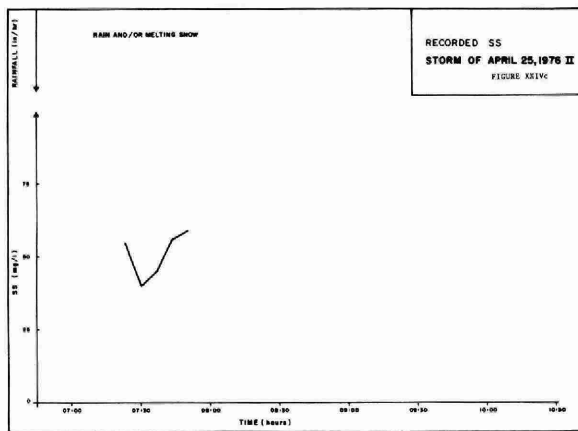


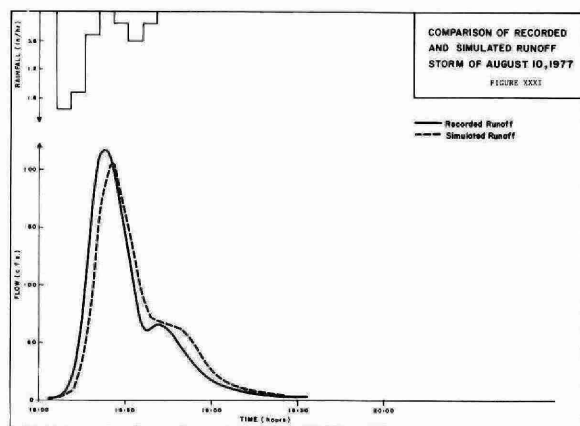
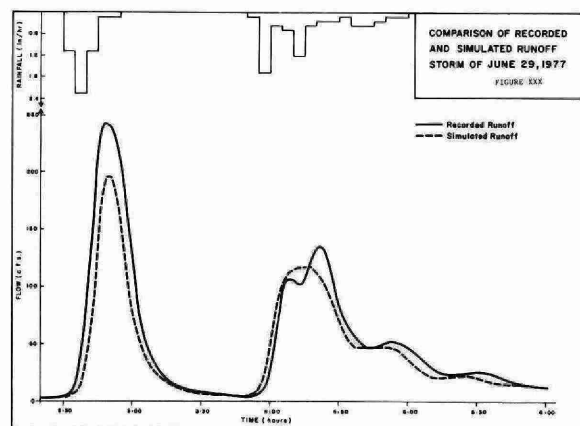
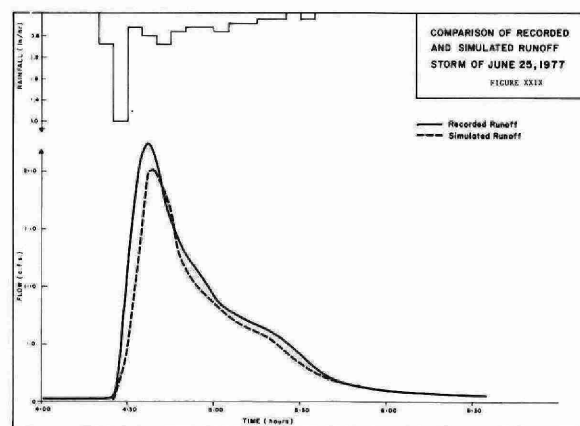
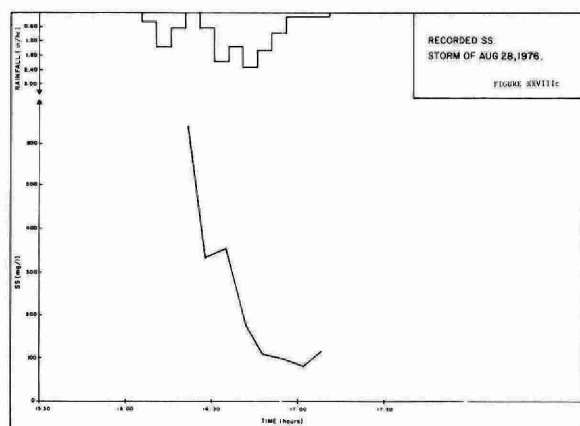
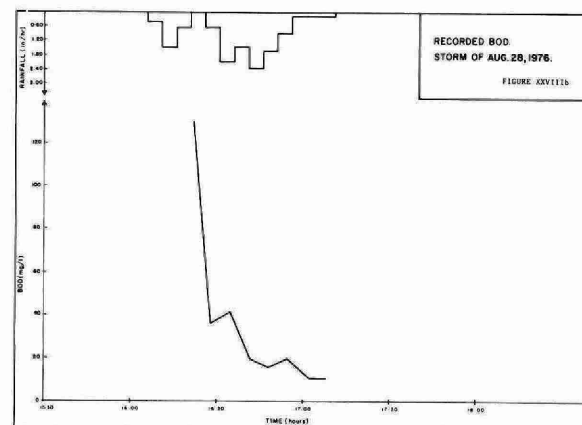
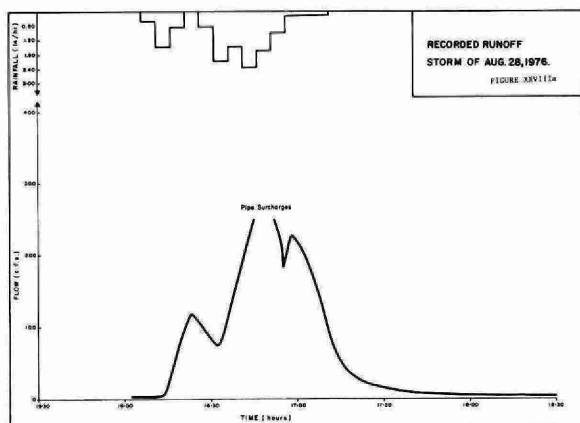
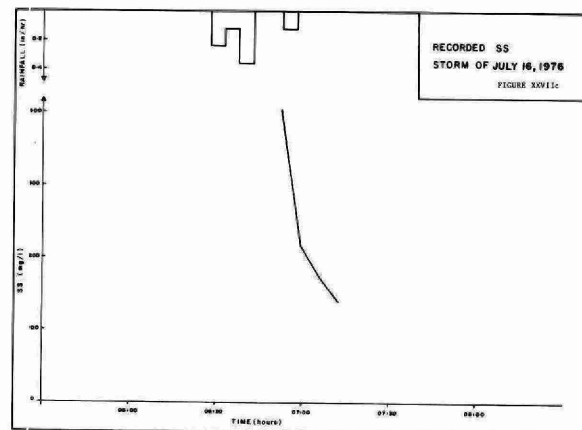
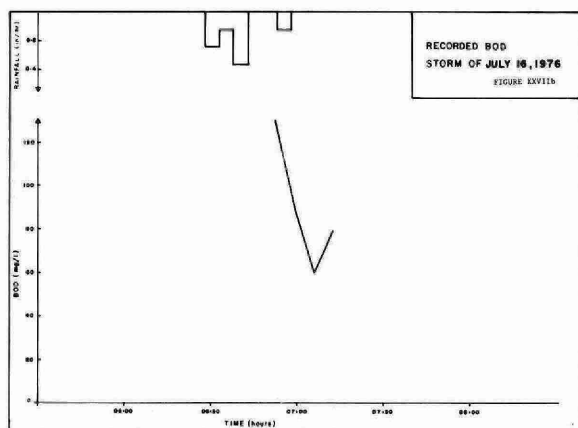












APPENDIX D
RUNOFF QUALITY DATA

Units are mg./litre unless otherwise indicated

RUNOFF QUALITY DATA

DATE DY/MO/YR	TIME HR:MN	FLOW c.f.s.	B.O.D	C.O.D	CHLORIDE AS Cl	SULPHATE AS SO ₄	CONDUCTIVITY UMHOS/CM	LEAD AS Pb	TOTAL PHOSPHORUS AS P	DISSOLVED REACTIVE PHOSPHORUS AS P	PHENOLS IN PPB*	NITROGEN AS N				SUSPENDED SOLIDS			DISSOLVED SOLIDS			TOTAL SOLIDS		
												FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS
06/12/75	05:45	18.3	95	1040	385	37	1500	1.20	4.30	0.36	9	4.4	17.0	0.16	1.0	630						1390	1000	390
	05:51	16.5	40	555	338	34	1300	1.60	2.50	0.24	8	2.7	11.0	0.16	1.2	470						1110	850	260
	05:58	18.5	35	315	232	26	920	1.20	1.70	0.22	6	2.4	7.5	0.12	1.1	310						815	610	205
	06:05	21.3	30	355	208	23	840	0.66	2.10	0.26	6	3.6	11.0	0.10	0.7	340						750	555	195
	06:11	20.5	20	235	162	19	660	0.97	1.30	0.18	5	2.2	6.0	0.10	0.7	220						560	425	135
	06:18	18.4	14	150	100	17	450	0.58	0.69	0.16	5	1.5	3.9	0.06	0.7	140						375	285	90
	06:25	15.8	14	110	86	17	400	0.56	0.63	0.22	5	2.2	3.7	0.06	0.9	100						315	215	100
	06:31	13.6	16	110	88	17	410	0.50	0.84	0.24	5	2.5	5.0	0.06	0.9	100						325	245	80
	06:38	12.0	11	83	79	18	385	0.50	0.80	0.28	6	2.7	4.6	0.06	0.9	90						305	220	85
	06:45	10.3	11	75	72	20	380	0.40	0.84	0.40	8	4.6	6.4	0.06	0.9	70						290	205	85
	06:51	9.0	11	75	64	20	375	0.36	0.88	0.44	6	5.3	7.2	0.06	1.3	70						265	190	75
	07:49	17.0	16	75	51	14	290	0.26	0.80	0.36	9	4.1	6.2	0.04	0.8	65						210	150	60
	07:55	17.8	10	63	46	13	255	0.18	0.60	0.28	7	3.1	4.6	0.04	0.6	60						200	145	55
	08:02	17.8	12	54	43	12	245	0.25	0.56	0.29	6	2.9	4.4	0.04	0.6	55						195	130	65
	08:09	17.8	11	67	42	12	240	0.27	0.64	0.34	7	3.4	5.0	0.04	0.6	110						200	140	60
	08:15	17.8	15	71	45	12	Exh.	0.35	0.76	0.34	7	4.7	6.6	0.04	0.6	70						225	130	90
	08:22	16.6	12	67	42	13	250	0.12	0.68	0.32	6	3.2	6.8	0.04	0.6	50						235	125	110
	08:29	15.5	15	67	47	14	295	0.30	1.20	0.72	8	7.7	10.0	0.04	0.8	70						200	140	60
	08:35	15.5	17	67	41	14	270	0.24	1.00	0.48	8	5.5	7.6	0.04	0.8	60						185	125	60
	08:42	16.8	18	69	40	13	270	0.21	1.20	0.62	9	7.4	10.0	0.04	0.6	55						190	115	75
	08:49	19.2	18	69	40	13	250	0.24	0.96	0.44	7	4.3	6.8	0.04	0.6	60						200	145	55
	08:55	20.5	17	77	41	12	255	0.27	1.30	0.66	7	6.1	8.4	0.04	0.6	70						200	130	70
	09:02	20.7	15	87	44	13	255	0.25	1.10	0.58	8	4.5	6.8	0.04	0.6	70						200	110	90
09/12/75	16:50	15.5	42	140	517	20	Exh.	0.12	0.92	0.20	6	3.0	5.6	0.06	0.7	70						1040	895	145
	16:56	16.1	17	100	511	21	1800	0.13	1.00	0.42	5	4.5	7.4	0.10	0.5	65						980	890	90
	17:03	16.6	11	120	519	22	1800	0.11	0.80	0.24	4	2.5	5.0	0.10	0.7	55						1000	910	90
	17:10	17.0	20	120	532	20	1850	0.15	0.88	0.22	4	2.2	5.4	0.08	0.5	70						1035	930	105
	17:16	16.6	14	100	520	19	Exh.	0.09	0.88	0.16	4	2.1	5.0	0.08	0.5	75						1025	910	115
	17:23	16.1	14	100	24	18	1550	0.11	0.80	0.18	4	3.1	6.4	0.12	0.5	90						825	745	80
	17:30	15.6	13	Exh.	414	20	Exh.	0.06	0.72	0.18	3	2.4	4.6	0.10	0.7	60						830	730	100
	17:36	15.3	14	Exh.	428	20	1550	0.13	0.64	0.10	6	2.4	4.4	0.20	0.4	55						850	770	80
	17:43	15.0	12	87	406	20	1460	0.11	0.76	0.24	4	2.8	5.0	0.12	0.7	50						820	740	80
	17:50	14.7	14	96	395	21	1430	0.09	0.76	0.20	5	2.0	4.2	0.10	0.7	50						790	720	70
	17:56	14.6	12	79	403	24	1460	0.09	0.84	0.22	4	2.3	4.8	0.12	0.7	60						790	740	50
	18:03	14.1	9	79	353	20	1280	0.08	0.80	0.28	5	3.1	5.4	0.14	0.7	60						705	650	55
	18:10	13.6	13	100	339	21	Exh.	0.08	1.00	0.28	3	2.8	5.6	0.12	0.7	50						700	640	60
	18:16	13.5	22	96	331	18	1200	0.10	1.00	0.08	4	1.4	5.2	0.04	0.2	65						675	580	95
	18:23	13.2	17	135	334	18	1220	0.06	1.00	0.14	4	2.5	5.8	0.12	0.3	65						680	610	70
	18:30	13.0	22	87	340	17	1260	0.07	0.92	0.18	3	3.0	6.0	0.14	0.3	65						695	615	80
	18:36	12.6	19	87	364	18	1300	0.06	0.96	0.20	3	3.0	6.4	0.10	0.5	55						690	630	60
	18:43	12.1	20	115	337	17	1250	0.16	1.00	0.26	4	2.8	6.2	0.08	0.3	60						690	620	70
	18:50	11.9	19	125	336	23	1280	0.07	1.40	0.40	4	4.3	8.2	0.10	0.3	65						715	640	75
	18:56	11.7	22	105	320	20	1220	0.16	1.10	0.24	4	2.4	6.0	0.06	0.2	60						675	600	75
	19:03	11.5	19	110	306	19	1180	0.07	0.96	0.18	3	3.0	6.2	0.14	0.3	55						665	575	90
	19:10	11.3	22	98	291	19	1120	0.12	0.96	0.18	3	2.3	5.4	0.12	0.3	60						620	560	60
	19:17	11.4	24	100	269	22	1100	0.12	1.70	0.68	4	3.6	7.6	0.14	0.3	65						620	555	65
	19:23	11.6	24	98	256	20	980	0.03	1.20	0.34	4	3.0	6.4	0.16	0.2	60						590	515	75

* Samples Unpreserved

Units are mg./litre unless otherwise indicated

RUNOFF QUALITY DATA

DATE DY/MO/YR	TIME HR:MN	FLOW c.f.s.	B.O.D	C.O.D	CHLORIDE AS Cl	SULPHATE AS SO ₄	CONDUCTIVITY UMHOS/CM	LEAD AS Pb	TOTAL PHOSPHORUS AS P	DISSOLVED REACTIVE PHOSPHORUS AS P	PHENOLS IN PPB *	NITROGEN AS N				SUSPENDED SOLIDS			DISSOLVED SOLIDS			TOTAL SOLIDS		
												FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS
30/12/75	14:46	19.2	61	255	747	37	2600	0.51	2.70	1.00	24	1.8	9.1	0.04	0.4	180	90	90	1480	1390	90	1660	1480	180
	14:52	20.8	65	495	718	37	2600	0.48	2.10	0.74	26	2.1	8.7	0.04	0.4	140	70	70	1440	1370	70	1580	1440	140
	14:59	20.8	75	260	687	34	2500	0.53	2.60	0.60	23	1.3	10.0	0.02	0.2	160	80	80	1470	1400	70	1630	1480	150
	15:06	20.0	64	250	683	33	2500	0.49	1.70	0.44	23	1.9	7.2	0.04	0.2	120	65	55	1380	1320	60	1500	1385	115
	15:12	19.0	43	280	697	33	2500	0.55	1.00	0.34	24	1.7	3.3	0.08	0.3	120	70	50	1440	1370	70	1560	1440	120
	15:19	18.8	45	160	712	33	2500	0.53	0.76	0.22	23	1.9	5.4	0.10	0.3	110	65	45	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.
	15:26	16.7	38	185	790	36	2900	0.53	1.20	0.36	24	3.3	6.8	0.08	0.3	120	70	50	1650	1610	40	1770	1680	90
	15:32	15.8	33	140	810	37	2950	0.46	1.00	0.20	25	2.6	5.6	0.28	0.3	105	70	35	1670	1620	50	1775	1690	85
	15:39	15.0	33	145	881	37	3150	0.43	0.84	0.14	26	1.8	4.7	0.34	0.5	100	60	40	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.
	15:46	14.2	35	140	916	38	3300	0.54	0.44	0.18	27	2.7	3.9	0.34	0.7	60	20	40	1760	1690	70	1820	1710	110
	15:52	13.3	31	185	930	40	3300	0.19	0.76	0.34	25	3.0	4.5	0.34	0.7	160	100	60	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.
	15:59	12.8	31	150	971	40	3400	0.32	0.68	0.20	25	3.1	5.8	0.30	0.5	140	80	60	1850	1760	90	1990	1840	150
	16:06	12.3	31	145	975	53	3550	0.44	0.84	0.18	24	2.7	5.6	0.44	0.8	110	60	50	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.
	16:12	11.5	38	160	1072	46	3600	0.54	0.96	0.30	26	3.6	6.2	0.40	1.0	150	90	60	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.
	16:19	10.7	35	235	1051	44	3800	0.57	1.00	0.42	25	4.3	6.6	0.46	0.5	140	80	60	2070	2000	70	2210	2080	130
	16:26	10.6	58	160	1025	46	3700	0.42	0.80	0.26	24	2.7	5.4	0.02	0.2	140	70	70	2070	1980	90	2210	2050	160
	16:32	10.6	53	160	1034	48	3800	0.26	1.00	0.30	28	3.9	7.2	0.16	0.2	100	60	40	1930	1840	90	2030	1900	130
	16:39	10.4	48	190	1091	55	4000	0.26	0.96	0.38	27	4.3	7.0	0.08	0.2	140	70	70	2070	1990	80	2210	2060	150
	16:46	10.0	58	245	1072	50	3900	0.27	1.20	0.34	28	4.1	7.4	0.04	0.2	140	80	60	2010	1940	70	2150	2020	130
	16:52	9.8	46	185	1080	50	3900	0.21	1.10	0.34	27	3.9	7.2	0.66	0.7	130	70	60	1960	1890	70	2090	1960	130
	16:59	9.7	44	155	1033	49	3800	0.21	1.00	0.32	25	4.9	8.0	0.36	0.4	130	70	60	1960	1880	80	2090	1950	140
	17:06	9.5	45	210	1007	49	3750	0.22	1.20	0.30	23	4.6	4.3	0.02	0.2	160	70	90	1890	1820	70	2050	1890	160
26/01/76	10:55	15.6	150	645	2290	62	7200	0.73	0.40	0.20	31	2.5	13.0	0.18	1.2	560	330	230	3650	3500	150	4210	3830	380
	11:01	15.7	35	245	2760	75	8400	0.05	1.20	0.32	24	3.8	8.0	0.70	1.3	150	60	90	4275	4240	35	4425	4300	125
	11:08	15.4	31	210	2831	75	8600	0.26	1.20	0.30	24	4.6	9.4	0.46	1.5	150	50	100	4380	4350	30	4530	4400	130
	11:15	15.4	19	180	2716	73	8400	0.32	1.70	0.42	20	3.7	8.4	0.40	1.6	120	50	70	4200	4150	50	4320	4200	120
	11:21	15.4	28	210	2902	78	8800	0.31	1.50	0.44	23	3.8	8.6	0.20	1.8	140	60	80	4580	4550	30	4720	4610	110
	11:28	15.5	33	165	2739	76	8200	0.25	1.40	0.32	22	3.2	7.6	0.20	1.8	140	60	80	4310	4260	50	4450	4320	130
	11:35	15.7	39	410	3064	80	9200	0.37	0.68	0.32	23	3.2	9.0	0.22	1.8	220	90	130	4850	4810	40	5070	4900	170
	11:41	16.0	34	265	2925	82	9000	0.32	1.30	0.34	24	3.2	8.4	0.22	1.8	190	90	100	4720	4660	60	4910	4750	160
	11:48	16.2	28	195	2708	74	8400	0.31	1.0	0.34	22	3.4	7.6	0.18	1.8	130	60	70	4690	4630	60	4820	4690	130
	11:55	16.3	46	225	2648	75	8000	0.29	1.30	0.42	24	4.1	9.8	0.20	1.8	150	70	80	4110	4090	20	4260	4160	100
	12:01	16.3	41	265	2609	72	8000	0.31	1.40	0.30	25	3.0	9.4	0.24	1.8	160	70	90	4240	4180	60	4400	4250	150
	12:08	16.3	26	235	2599	74	8200	0.30	1.20	0.32	24	3.5	6.8	0.20	1.8	130	60	70	4080	4060	20	4210	4120	90
	12:15	16.2	22	190	2400	72	7600	0.27	0.92	0.30	22	4.5	8.2	0.20	1.8	120	50	70	3870	3850	20	3990	3900	90
	12:21	16.2	23	245	2314	70	7000	0.17	1.90	0.80	22	4.6	11.0	0.18	1.8	130	70	60	3540	3510	30	3670	3580	90
	12:28	16.2	44	255	2961	84	9000	0.72	0.88	0.40	23	3.2	9.2	0.20	1.6	290	160	130	4410	4370	40	4700	4530	170
	12:35	16.2	33	220	2578	75	8000	0.51	1.00	0.38	23	4.0	9.0	0.22	1.8	190	100	90	4080	4030	50	4270	4130	140
	12:41	16.2	27	275	2364	69	7500	0.42	0.72	0.30	23	4.3	9.0	0.20	1.8	140	60	80	3790	3740	50	3930	3800	130
	12:48	16.2	42	225	2250	68	7000	0.41	1.00	0.24	23	4.2	8.6	0.20	1.8	140	70	70	3560	3530	30	3700	3600	100
	12:55	16.2	33	180	2192	67	7000	0.42	0.76	0.22	23	4.2	7.8	0.20	1.8	130	60	70	3470	3440	30	3600	3500	100
	13:01	16.2	24	180	2147	67	6800	0.40	0.92	0.16	24	3.9	7.2	0.22	1.8	110	50	60	3400	3370	30	3510	3420	90
	13:08	16.2	25	255	2164	67	6800	0.43	0.80	0.16	23	3.9	7.2	0.18	1.8	120	50	70	3140	3090	50	3270	3150	120
	13:15	15.9	13	260	2021	Exh.	6300	0.45	0.92	0.44	21	4.8	8.6	0.20	1.8	130	60	70	3140	3090	50	3270	3150	120
	13:21	15.4	24	180	2036	73	6600	0.42	1.00	0.36	24	4.0	8.0	0.22	1.8	150	70	80	3350	3290	60	3500	3360	140
	13:28	14.8	24	315	2032	Exh.	6400	0.45	1.10	0.24	23	2.2	7.6	0.16	2.0	150	80	70	3290	3220	70	3340	3200	140

* Samples Unpreserved

Units are mg./litre unless otherwise indicated

RUNOFF QUALITY DATA

DATE	TIME	FLOW c.f.s.	B.O.D	C.O.D	CHLORIDE AS Cl	SULPHATE AS SO ₄	CONDUCTIVITY UMHOS/CM	LEAD AS Pb	TOTAL PHOSPHORUS AS P	DISSOLVED REACTIVE PHOSPHORUS AS P	PHENOLS IN PPB *	NITROGEN AS N				SUSPENDED SOLIDS			DISSOLVED SOLIDS			TOTAL SOLIDS		
												FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS
05/03/76	08:13	19.0	80	215	216	29	940	0.19	2.00	0.54	15	6.3	9.2	0.06	0.8	160	75	85	480	420	60	640	495	145
	08:19	22.0	65	180	174	23	760	0.25	2.20	0.54	15	5.5	12.0	0.04	0.6	185	100	85	370	325	45	555	425	130
	08:26	25.8	66	160	141	21	630	0.28	2.00	0.30	14	3.9	10.0	0.06	0.4	185	100	85	325	280	45	510	380	130
	08:33	28.2	51	140	176	22	740	0.32	1.60	0.38	14	3.8	8.8	0.08	0.5	155	85	70	385	345	40	540	430	110
	08:39	25.7	51	130	152	21	650	0.40	1.00	0.34	14	3.4	7.0	0.10	0.6	140	85	55	375	325	50	515	410	105
	08:46	24.7	25	91	146	21	630	0.30	1.10	0.30	14	3.5	6.6	0.10	0.7	120	75	45	320	270	50	440	345	95
	08:53	23.7	37	100	165	22	690	0.16	1.00	0.24	15	2.2	5.4	0.11	0.7	110	70	40	400	350	50	510	420	90
	08:59	22.0	26	91	173	22	710	0.18	0.92	0.24	15	1.5	4.4	0.12	0.8	85	50	35	405	350	55	490	400	90
	09:06	20.5	28	82	170	24	720	0.19	0.84	0.28	16	2.8	4.6	0.10	0.9	95	65	30	395	325	70	490	390	100
	09:13	19.3	27	75	188	25	770	0.21	0.92	0.28	17	3.3	6.4	0.11	1.0	90	60	30	425	380	45	515	440	75
	09:19	18.5	22	71	200	25	820	0.20	0.80	0.24	17	2.7	4.8	0.10	1.1	70	45	25	450	400	50	520	445	75
	09:26	17.9	34	95	211	25	865	0.20	0.88	0.22	17	2.2	5.0	0.14	0.9	75	45	30	465	400	65	540	450	90
	09:33	17.8	27	84	235	26	970	0.15	1.00	0.36	18	3.9	6.6	0.07	1.2	60	35	25	525	475	50	585	510	75
	09:39	17.5	29	80	267	29	1070	0.18	0.92	0.20	18	2.6	5.4	0.08	1.2	70	35	35	590	535	55	660	570	90
	09:46	16.8	26	100	282	29	1130	0.19	0.92	0.20	18	2.1	4.6	0.09	1.3	65	35	30	600	560	40	665	595	70
	09:53	15.8	45	125	323	31	1290	0.20	1.60	0.54	19	3.8	5.8	0.09	1.2	95	40	55	675	635	40	770	675	95
	09:59	15.1	36	110	321	34	1260	0.23	1.00	0.20	19	2.8	3.2	0.14	1.3	80	45	35	660	600	60	740	645	95
	10:06	14.2	31	135	320	37	1260	0.22	0.88	0.22	19	2.0	4.8	0.08	1.3	65	35	30	700	635	65	765	670	95
	10:13	13.0	29	80	332	36	1300	0.25	1.00	0.34	19	3.3	6.0	0.08	1.5	66	35	31	628	592	36	694	627	67
	10:19	12.6	36	71	339	36	1340	0.26	1.00	0.34	18	3.2	6.0	0.09	1.5	115	90	25	705	665	40	820	755	65
	10:26	13.3	54	82	350	38	1400	0.14	1.10	0.28	20	2.8	5.8	0.14	1.3	65	30	35	740	700	40	805	735	70
	10:33	14.0	32	91	352	39	1410	0.19	1.20	0.42	20	4.5	7.8	0.09	1.4	65	25	40	735	700	35	800	725	75
27/03/76	14:48	28.3	220	1090	138	35	680	2.60	5.20	0.50	6	2.4	26.0	0.06	0.1	2115	1115	1000	505	315	190	2620	1430	1190
	14:54	26.5	100	755	138	35	670	2.30	4.20	0.50	5	1.7	21.0	0.09	0.4	1295	825	470	425	315	110	1720	1140	580
	15:01	21.0	50	390	111	34	510	1.60	2.20	0.32	3	2.1	12.0	0.08	0.8	495	310	185	325	265	60	820	575	245
	15:08	18.0	50	415	105	33	540	1.10	3.60	0.34	4	2.2	15.0	0.15	1.1	440	235	205	355	260	95	795	495	300
	15:14	14.3	50	385	105	33	530	0.96	3.90	0.28	5	2.2	14.0	0.21	0.6	415	410	5	310	225	85	725	635	90
	15:21	12.6	38	250	98	33	520	0.80	1.50	0.18	3	1.8	8.6	0.11	0.9	285	165	120	310	225	85	595	390	205
	15:28	11.7	40	155	91	34	490	0.62	1.50	0.24	3	2.0	7.8	0.11	1.2	200	105	95	275	210	65	475	315	160
	15:34	12.8	45	230	71	35	460	0.46	1.30	0.26	4	2.1	6.6	0.11	1.1	140	55	85	250	160	90	390	215	175
	15:41	20.7	22	170	63	29	390	0.62	1.00	0.18	3	2.0	5.4	0.06	0.8	150	85	65	230	170	60	380	255	125
	15:48	25.4	20	165	51	25	325	0.63	0.96	0.20	3	1.8	6.0	0.06	0.7	185	100	85	190	130	60	375	230	145
	15:54	22.5	18	130	53	22	325	0.53	1.00	0.16	2	2.4	5.6	0.08	0.9	135	80	55	190	145	45	325	225	100
	16:01	19.2	16	100	52	21	325	0.40	0.92	0.24	2	1.5	4.6	0.06	1.0	100	50	50	210	165	45	310	215	95
	16:08	16.0	14	100	54	23	340	0.40	0.72	0.10	1	1.0	3.8	0.08	1.1	105	55	50	185	155	30	290	210	80
	16:14	12.5	15	115	63	27	400	0.37	0.88	0.10	2	1.4	4.8	0.10	1.2	95	45	50	230	165	65	325	210	115

* Samples Unpreserved

Units are mg./litre unless otherwise indicated

RUNOFF QUALITY DATA

DATE DY/MO/YR	TIME HR:MN	FLOW c.f.s.	B.O.D	C.O.D	CHLORIDE AS Cl	SULPHATE AS SO ₄	CONDUCTIVITY UMHOS/CM	LEAD AS Pb	TOTAL PHOSPHORUS AS P	DISSOLVED REACTIVE PHOSPHORUS AS P	PHENOLS IN PPB *	NITROGEN AS N				SUSPENDED SOLIDS			DISSOLVED SOLIDS			TOTAL SOLIDS		
												FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS
31/03/76	08:49	17.0	112	250	54	25	380	0.22	1.2	0.26	3	2.6	6.8	0.07	1.0	95	25	70	290	185	105	385	210	175
	08:55	16.7	25	130	53	23	375	0.26	1.4	0.38	3	3.6	8.2	0.07	1.1	95	35	60	220	160	60	315	195	120
	09:02	15.5	20	125	53	25	370	0.20	1.4	0.50	2	4.6	8.8	0.07	1.1	100	35	65	215	165	50	315	200	115
	09:09	13.7	29	115	57	25	405	0.20	1.3	0.46	2	4.1	8.4	0.07	1.3	75	20	55	210	175	35	285	195	90
	09:15	13.0	24	110	62	26	405	0.18	1.3	0.38	2	4.1	8.6	0.07	1.3	75	20	55	240	180	60	315	200	115
	09:22	13.3	20	105	57	25	390	0.20	1.1	0.28	3	2.4	6.0	0.07	1.2	65	15	50	180	160	20	245	175	70
	09:29	14.9	22	74	49	22	350	0.22	1.0	0.30	2	2.4	6.0	0.06	1.1	80	20	60	195	145	50	275	165	110
	09:35	17.6	25	120	42	21	300	0.26	0.92	0.28	3	1.9	5.0	0.05	1.0	100	40	60	150	105	45	250	145	105
	09:42	20.2	24	125	39	19	275	0.27	1.00	0.40	3	1.1	4.4	0.05	0.8	125	40	85	180	140	40	305	180	125
	09:49	21.1	20	105	37	23	285	0.26	1.00	0.30	2	1.8	4.8	0.04	0.9	90	30	60	170	130	40	260	160	100
	09:55	20.9	18	99	35	18	260	0.24	0.84	0.24	2	1.1	3.6	0.04	0.8	75	25	50	155	110	45	230	135	95
	10:02	20.2	23	150	37	18	265	0.28	1.10	0.20	3	0.9	4.2	0.06	0.7	110	25	85	175	115	60	285	140	145
	10:09	18.0	15	90	41	25	300	0.24	1.20	0.34	2	1.7	4.8	0.05	1.0	80	20	60	195	145	50	275	165	110
	10:15	16.5	14	74	44	21	300	Exh.	0.92	0.26	2	1.2	4.0	0.05	1.0	50	5	45	195	165	30	245	170	75
	10:22	17.3	15	110	45	20	300	0.22	0.64	0.24	1	1.6	4.2	0.05	1.0	55	-	-	195	145	50	250	140	110
	10:29	17.3	15	82	43	25	310	0.18	1.00	0.30	2	1.4	4.8	0.05	1.0	62	-	-	200	140	60	260	130	130
	10:35	16.0	20	82	45	28	325	0.18	1.10	0.22	2	1.1	4.2	0.05	1.0	60	1	59	215	164	51	275	165	110
	10:42	14.2	20	92	49	25	360	0.22	1.00	0.34	1	2.5	5.4	0.06	1.1	50	-	-	200	175	25	250	150	100
	10:49	13.6	20	88	49	30	360	0.20	1.00	0.34	2	2.0	5.0	0.06	1.1	40	-	-	250	200	50	290	180	110
	10:55	13.5	36	120	49	26	360	0.17	0.80	0.28	2	1.6	4.8	0.36	0.8	50	-	-	240	195	45	290	185	105
	11:02	13.4	62	240	48	27	360	0.19	1.60	0.40	3	2.0	8.6	0.30	0.5	115	-	-	220	190	30	335	180	155
	11:09	13.0	25	91	49	29	375	0.20	1.20	0.36	2	2.0	5.6	0.05	1.2	80	5	75	220	195	25	300	200	100
	11:15	13.8	20	100	49	25	330	0.26	0.88	0.36	8	0.8	4.0	0.02	1.2	120	40	80	200	170	30	320	210	110
	11:22	18.7	25	125	37	22	290	0.26	1.40	0.38	2	1.1	5.6	0.06	0.7	180	95	85	210	185	25	390	280	110
22/04/76	22:36	21.4	115	370	82	35	540	0.28	4.50	0.76	5	5.4	21.0	0.10	0.2	285	125	160	345	250	95	630	375	255
	22:42	21.4	56	280	36	35	280	0.22	4.30	0.40	4	2.4	17.0	0.11	0.4	265	145	120	170	120	50	435	265	170
	22:49	16.9	44	230	43	30	335	0.19	2.40	0.40	3	3.0	9.0	0.11	0.7	265	125	140	160	135	25	425	260	165
	22:56	12.8	50	205	50	28	380	0.17	2.30	0.32	2	3.5	9.5	0.10	0.5	200	75	125	210	165	45	410	240	170
	23:02	9.7	54	165	72	35	490	0.13	2.10	0.24	2	4.0	9.5	0.21	0.6	145	40	105	260	230	30	405	270	135
24/04/76	23:52	18.8	68	290	39	20	275	0.16	2.90	0.56	9	1.5	9.8	0.05	0.8	185	65	120	165	120	45	350	185	165
	23:58	19.9	24	185	32	24	250	0.15	2.00	0.48	6	3.0	8.0	0.06	0.9	165	90	75	135	95	40	300	185	115
25/04/76	00:05	19.2	16	100	34	17	235	0.11	1.10	0.28	4	2.3	5.6	0.04	1.1	145	70	75	145	105	40	290	175	115
	00:12	16.4	14	105	40	17	255	0.09	1.00	0.28	4	2.4	5.4	0.05	1.1	100	60	40	125	90	35	225	150	75
	00:18	14.0	17	89	37	17	270	0.04	1.00	0.26	4	2.3	5.4	0.04	1.4	100	60	40	180	135	45	280	195	85
	00:25	11.5	11	75	50	20	310	0.07	0.84	0.24	4	2.0	4.0	0.05	1.6	90	50	40	180	140	40	270	190	80
	00:32	9.5	21	81	58	Exh.	340	Exh.	0.68	0.18	4	1.7	3.8	0.04	2.2	65	35	30	215	155	60	280	190	90
25/04/76	02:08	17.0	11	69	32	15	215	0.05	0.72	0.16	4	1.0	3.0	0.03	1.3	65	35	30	150	105	45	215	140	75
	02:14	15.6	7	48	33	17	220	Exh.	0.52	0.20	3	1.3	3.2	0.03	1.3	85	60	25	90	70	20	175	130	45
	02:21	13.7	6	60	37	15	245	0.03	0.52	0.24	3	1.4	3.4	0.04	1.4	60	35	25	135	120	15	195	155	40
	02:28	12.0	4	41	41	16	255	0.04	0.36	0.18	3	1.2	2.6	0.04	1.5	55	35	20	140	115	25	195	150	45
	02:34	10.4	8	56	47	17	300	0.05	0.52	0.30	3	1.7	3.6	0.04	1.7	50	30	20	155	120	35	205	150	55
	02:41	9.2	9	52	54	19	330	0.05	0.40	0.18	4	1.4	3.0	0.04	2.0	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.
25/04/76	07:24	17.3	13	46	33	14	225	0.02	0.56	0.26	3	1.1	3.6	0.04	1.2	55	30	25	145	100	45	200	130	70
	07:30	18.5	9	41	29	13	200	0.03	0.56	0.32	3	1.2	4.4	0.03	1.0	40	20	20	110	85	25	150	105	45
	07:37	19.8	8	56	31	12	190	0.03	0.60	0.28	3	1.3	4.4	0.03	0.9	45	20	25	115	85	30	160	105	55
	07:44	20.1	10	72	35	15	265	0.01	0.92	0.50	4	1.8	7.0	0.03	1.2	56	28	28	140	94	46	196	122	74
	07:50	19.4	13	93	58	24	425	0.02	1.30	0.72	4	2.9	11.0	0.04	1.0	59	28	32	202	154	48	261	182	80

* Samples Unpreserved

RUNOFF QUALITY DATA

DATE DY/MO/YR	TIME HR MN	FLOW c.f.s.	B.O.D	C.O.D	CHLORIDE AS Cl	SULPHATE AS SO ₄	CONDUCTIVITY UMHOS/CM	LEAD AS Pb	TOTAL PHOSPHORUS AS P	DISSOLVED REACTIVE PHOSPHORUS AS P	PHENOLS IN PPB *	NITROGEN AS N				SUSPENDED SOLIDS			DISSOLVED SOLIDS			TOTAL SOLIDS		
												FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS
06/05/76	09:59	19.1	32	110	49	14	270	0.12	1.10	0.20	6	1.2	4.8	0.06	0.5	82	34	48	150	102	48	232	136	96
	10:05	18.2	22	83	67	13	330	0.12	0.68	0.16	4	1.1	3.8	0.06	0.7	69	30	39	184	138	46	253	168	85
	10:12	16.4	18	62	70	15	360	0.10	0.96	0.32	7	3.2	5.6	0.08	0.8	59	22	37	204	174	30	263	196	67
	10:19	13.8	40	110	93	16	445	0.10	0.76	0.20	6	1.8	4.0	0.09	0.9	52	23	29	256	184	72	308	207	101
	10:25	12.3	40	110	112	19	550	0.10	1.00	0.20	7	2.8	5.8	0.10	0.5	69	21	48	316	276	40	385	297	88
	10:32	10.8	36	112	103	23	640	Exh.	1.20	0.26	8	2.2	5.0	0.10	0.9	59	19	40	376	334	42	435	353	82
	10:39	11.3	32	85	62	25	390	0.07	1.00	0.20	8	1.7	5.0	0.14	1.1	54	14	40	206	202	4	260	216	44
	10:45	12.8	30	73	43	20	315	0.08	0.92	0.34	8	3.0	5.0	0.10	1.0	45	10	35	158	158	-	203	168	35
	10:52	13.7	24	59	37	16	280	0.07	0.84	0.18	7	1.6	4.0	0.08	0.9	42	8	34	138	136	2	180	144	36
	10:59	13.4	38	73	37	15	267	0.07	0.60	0.16	7	1.2	3.0	0.08	0.9	38	9	29	138	136	2	176	145	31
	11:05	12.8	24	61	41	16	287	0.07	0.92	0.22	7	2.0	4.4	0.10	1.0	42	14	28	338	326	12	380	340	40
	11:12	11.1	38	54	44	22	334	0.08	1.20	0.48	7	1.9	4.8	0.10	1.1	46	11	35	194	169	25	240	180	60
	11:19	9.7	32	73	62	23	420	0.05	1.10	0.36	6	3.0	5.4	0.12	1.6	37	4	33	220	212	8	257	216	41
06/05/76	13:27	15.3	30	93	42	16	275	0.08	1.00	0.12	6	1.0	4.6	0.10	1.9	41	11	30	178	162	16	219	173	46
	13:33	14.0	30	86	38	18	269	0.09	1.00	0.18	6	1.0	3.8	0.10	0.8	56	18	38	178	160	18	234	178	56
	13:40	11.8	30	73	40	17	280	0.12	1.20	0.20	7	1.4	4.2	0.13	0.9	52	16	36	152	136	16	204	152	52
	13:47	11.3	28	86	47	20	325	0.08	1.10	0.30	8	1.4	3.8	0.12	1.1	52	18	34	202	168	34	254	186	68
	13:53	9.8	36	95	51	23	367	0.08	1.30	0.44	10	2.5	5.8	0.10	1.1	60	13	47	210	194	16	270	207	63
	14:00	9.4	36	73	58	23	400	0.06	1.50	0.28	9	1.6	6.6	0.16	1.0	42	4	38	230	194	36	272	198	74
	14:07	9.2	38	91	59	23	396	0.06	1.00	0.28	7	2.6	5.2	0.18	1.3	32	1	31	244	204	40	276	205	71
	14:13	10.3	24	73	49	20	350	0.08	0.68	0.24	7	2.7	4.6	0.13	1.3	32	5	27	190	172	18	222	177	45
	14:20	12.6	32	84	Exh.	19	295	Exh.	1.00	0.20	8	2.0	5.6	0.08	0.8	38	11	27	150	130	20	188	141	47
11/05/76	15:50	30.5	100	335	40	24	330	0.46	3.30	0.76	6	2.7	13.0	0.13	2.8	334	191	143	334	322	12	668	513	155
	15:56	29.0	95	270	33	18	255	0.49	3.80	0.52	6	2.2	11.0	0.11	0.9	377	215	162	160	144	16	537	359	178
	16:03	33.7	65	210	24	15	210	0.42	1.50	0.30	6	1.4	8.6	0.08	0.7	260	139	121	138	128	10	398	267	131
	16:10	35.8	60	150	18	13	190	0.30	0.80	0.18	5	1.1	7.0	0.08	0.6	221	113	108	114	-	-	335	233	102
	16:16	26.0	65	150	24	11	180	0.30	0.96	0.12	5	1.0	6.0	0.06	0.4	191	96	95	72	40	32	263	136	127
	16:23	17.4	40	95	36	14	245	0.20	0.36	0.08	4	0.6	3.6	0.09	1.3	104	43	61	120	100	20	224	143	81
	16:30	12.2	40	100	47	16	305	0.19	1.10	0.12	4	0.9	4.0	0.10	1.5	99	48	51	180	162	18	279	210	69
	16:36	8.6	30	100	Exh.	27	490	0.18	1.40	0.32	4	1.7	5.8	0.14	2.2	90	36	53	272	232	40	362	268	93
01/06/76	11:19	22.2	130	400	37	19	295	0.30	2.60	0.24	9	1.6	12.0	0.08	0.8	206	71	135	232	154	78	438	225	213
	11:25	21.9	44	150	44	19	250	0.13	1.40	0.22	8	0.9	6.2	0.08	0.9	115	49	66	170	144	26	285	193	92
	11:32	19.1	40	145	48	19	275	0.21	1.10	0.12	7	0.7	5.2	0.07	1.0	83	32	51	156	148	8	239	180	59
	11:39	15.7	24	120	56	20	305	0.18	1.10	0.20	6	0.9	5.0	0.06	1.1	75	31	44	168	154	14	243	185	58
	11:45	13.1	24	105	Exh.	21	365	0.12	0.80	0.16	7	1.0	5.4	0.06	1.5	51	16	35	196	180	16	247	196	51
	11:52	10.8	24	175	Exh.	27	440	0.10	0.84	0.06	7	0.2	5.0	0.06	2.3	53	10	43	266	240	26	319	250	69
28/06/76	23:22	19.0	280	173	36	19		0.16	1.80	0.30	4	2.4	9.0	0.17	0.3	131	40	91	196	98	98	327	138	189
	23:29	15.4	48	117	36	18		0.15	1.60	0.26	3	2.8	8.6	0.31	0.3	103	30	73	174	102	72	277	132	145
	23:35	12.0	42	113	47	20		0.11	1.10	0.22	2	3.3	6.8	0.36	0.7	70	22	48	184	114	70	254	136	118
30/06/76	08:31	17.4	80	139	58	32		0.10	1.80	0.52	3	3.7	12.0	0.01	0.2	83	18	65	226	174	52	309	192	117
	08:37	20.2	30	101	31	26		0.10	1.40	0.72	3	4.6	8.0	0.38	0.8	54	16	38	140	106	34	194	122	72
	08:44	28.6	34	125	25	23		0.14	1.70	0.64	3	4.3	8.8	0.09	0.2	92	32	60	118	116	2	210	148	62
	08:51	36.9	42	133	20	21		0.18	1.90	0.80	3	3.6	9.1	0.02	0.2	128	59	69	122	112	10	250	171	79
	08:57	34.4	30	117	19	19		0.14	1.50	0.52	2	3.1	7.2	0.05	0.1	107	52	55	120	98	22	227	150	77
	09:04	28.6	24	72	24	20		0.10	1.20	0.54	2	2.5	5.2	0.18	0.5	74	35	39	120	102	18	194	137	57
	09:11	23.2	22	58	27	18		0.08	0.84	0.46	2	3.6	5.6	0.28	0.8	47	20	27	124	90	34	171	110	61
	09:17	18.8	20	60	31	17		0.06	0.64	0.20	1	2.1	3.8	0.11	1.7	39	11	28	142	108	34	181	119	62
	09:24	15.6	24	38	36	22		0.06	1.00	0.62	2	4.0	5.6	0.23	0.7	37	12	25	178	152	26	215	164	51
	09:31	13.2	19	58	42	22		0.06	1.20	0.86	2	4.9	6.8	0.25	1.0	38	7	31	136	130	6	174	137	37
	09:37	10.7	18	52	57	24		0.03	1.20	0.84	1	6.1	7.8	0.30	1.1	38	15	23	192	156	36	230	171	59

* Samples Unpreserved

Units are mg./litre unless otherwise indicated

RUNOFF QUALITY DATA

DATE DY/MO/YR	TIME HR:MN	FLOW c.f.s.	B.O.D	C.O.D	CHLORIDE AS Cl	SULPHATE AS SO ₄	CONDUCTIVITY UMHOS/CM	LEAD AS Pb	TOTAL PHOSPHORUS AS P	DISSOLVED REACTIVE PHOSPHORUS AS P	PHENOLS IN PPB *	NITROGEN AS N				SUSPENDED SOLIDS			DISSOLVED SOLIDS			TOTAL SOLIDS		
												FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS
30/06/76	11:24	20.0	30	62	32	19		0.08	0.76	0.38	2	2.3	4.6	0.14	0.4	46	14	32	152	122	30	198	136	62
	11:30	17.4	24	72	35	22		0.10	1.00	0.50	1	2.4	5.3	0.11	0.3	53	18	35	178	146	32	231	164	67
	11:37	14.6	36	60	39	23		0.08	1.70	1.10	1	1.4	4.6	0.05	0.1	48	17	31	176	148	28	224	165	59
	11:44	11.9	22	60	50	26		0.06	1.00	0.52	1	2.4	4.8	0.41	1.0	38	15	23	230	186	44	268	201	67
	11:50	9.6	26	Exh.	65	30		0.06	0.92	Exh.	2	Exh.	5.2	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.
01/07/76	08:34	17.4	70	169	44	21	300	0.01	2.00	0.64	3	5.9	11.0	0.01	<0.1	105	58	47	210	148	62	315	206	109
	08:41	23.3	42	133	31	16	219	0.01	2.20	0.84	3	4.8	9.8	0.01	<0.1	103	37	66	160	120	40	263	157	106
	08:48	30.0	40	111	26	13	182	0.08	1.60	0.62	2	3.4	7.4	0.04	<0.1	93	38	55	148	106	42	241	144	97
	08:54	26.8	22	84	30	12	187	0.06	1.10	0.46	1	3.3	6.0	0.07	0.4	63	19	44	144	96	48	207	115	92
	09:01	21.3	17	52	40	15	231	0.09	0.88	0.48	1	3.9	5.6	0.09	0.8	47	13	34	162	128	34	209	141	68
	09:08	15.5	22	90	46	19	289	0.06	1.20	0.72	1	4.2	6.6	0.13	0.7	45	12	33	202	170	32	247	182	65
	09:14	11.7	27	70	60	22	381	0.04	1.30	0.90	1	8.2	12.0	0.28	0.7	45	11	34	196	180	16	241	191	50
01/07/76	17:09	87.0	110	444	46	18	289		3.50	0.42	6	2.0	15.0	0.01	0.1	473	265	208	218	158	60	691	423	268
	17:15	94.0	45	222	20	10	142	0.36	2.00	0.12	3	0.7	8.5	0.05	0.1	350	230	120	20120	20090	30	20470	20320	150
	17:22	53.0	40	224	18	8	129	0.13	1.90	0.10	3	0.4	6.5	0.04	0.3	320	210	110	120	82	38	440	292	148
	17:29	27.0	26	109	36	12	205	0.06	1.10	0.06	2	1.0	4.6	0.06	0.6	141	92	49	144	108	36	285	200	85
	17:35	15.8	28	169	48	16	275	Exh.	1.10	0.10	2	1.4	5.4	0.10	0.7	154	96	58	178	130	48	332	226	106
	17:42	10.6	22	119	70	23	385	Exh.	0.76	0.18	2	2.4	5.0	0.22	1.3	96	47	49	242	186	56	338	233	105
02/07/76	11:50	19.5	55	149	37	17	231	0.04	0.88	0.16	9	1.2	4.2	0.04	0.6	68	21	47	194	136	58	262	157	105
	11:57	19.5	32	82	34	14	196	0.05	0.60	0.08	10	0.7	3.0	0.06	0.7	38	9	29	154	122	32	192	131	61
	12:03	20.1	30	620	30	12	176	0.06	0.48	0.02	10	0.6	2.6	0.05	0.5	34	9	25	128	106	22	162	115	47
	12:10	21.8	26	70	29	13	180	0.06	0.52	0.14	9	0.9	2.8	0.05	0.6	39	13	26	138	104	34	177	117	60
	12:17	22.0	24	84	31	13	180	0.10	0.36	0.08	11	0.4	2.8	0.06	0.8	34	12	22	144	98	46	178	110	68
	12:23	18.2	24	72	39	15	216	0.06	0.56	0.12	10	1.3	3.2	0.07	0.8	34	12	22	160	114	46	194	126	68
	12:30	14.9	30	66	43	17	253	0.08	0.56	0.06	9	1.1	2.8	0.07	0.9	31	10	21	188	148	40	219	158	61
	12:37	12.3	33	76	45	19	270	0.09	0.56	0.06	7	1.2	3.2	0.08	0.9	30	4	26	186	154	32	216	158	58
	12:43	10.1	42	78	62	25	361	0.04	1.00	0.32	7	1.4	4.4	0.22	1.0	31	6	25	250	202	48	281	208	73
07/07/76	18:56	29.0	180	565	95	25	340	0.34	5.00	0.96	15	2.6	20.0	<0.01	0.1	315	108	207	250	144	106	565	252	313
	19:03	42.5	110	355	70	18	265	0.35	3.40	0.46	60	0.1	13.0	<0.01	0.1	243	98	145	194	122	72	437	220	217
	19:10	46.7	90	275	54	15	210	0.35	2.60	0.16	12	<0.1	10.0	<0.01	0.1	234	111	123	156	94	62	390	205	185
	19:16	44.6	70	220	48	13	175	0.26	2.00	0.04	8	<0.1	7.5	<0.01	0.1	169	85	84	130	74	56	299	159	140
	19:23	41.5	60	200	42	11	150	0.20	2.20	0.04	7	<0.1	7.0	<0.01	0.1	124	59	65	98	44	54	222	103	119
	19:30	31.2	42	110	40	10	142	0.14	0.90	0.02	3	<0.1	3.9	<0.01	0.1	112	60	52	94	54	40	206	114	92
	19:36	21.3	40	105	63	13	Exh.	0.08	1.10	0.02	2	<0.1	4.4	<0.01	0.1	96	37	59	124	64	60	220	101	119
	19:43	15.0	38	110	80	19	Exh.	0.05	1.00	0.06	48	<0.1	4.2	<0.01	<0.1	50	17	33	146	102	44	196	119	77
	19:50	10.9	36	95	116	24	Exh.	0.08	1.20	0.16	33	1.2	5.5	0.01	<0.1	52	14	38	180	152	28	232	166	66
11/07/76	01:25	18.4	65	Exh.	21	16	Exh.	0.04	1.10	0.04	2	<0.1	4.6	<0.01	<0.1	71	18	53	188	102	86	259	120	139
	01:32	18.8	30	Exh.	18	15	190	0.08	1.10	0.32	2	1.3	4.2	0.03	<0.1	70	22	48	128	84	44	198	106	92
	01:39	17.3	20	Exh.	20	14	190	0.09	0.68	0.16	2	0.9	3.0	0.14	0.4	50	15	35	122	82	40	172	97	75
	01:45	15.6	18	Exh.	22	14	205	0.13	0.52	0.14	2	1.3	2.9	0.20	0.5	34	8	26	126	82	44	160	90	70
	01:52	13.1	14	Exh.	25	15	220	0.05	0.56	0.22	2	1.2	2.6	0.25	0.1	30	5	25	118	72	46	148	77	71
	01:59	10.8	19	Exh.	35	17	270	0.09	0.56	0.20	1	1.1	2.7	0.33	0.6	24	3	21	160	104	56	184	107	77
16/07/76	06:53	21.1	130	625	28	26		0.32	5.20	0.92	30	6.2	25.0	<0.01	<0.1	403	125	278	290	134	156	693	259	434
	06:59	17.3	90	310	27	25		0.22	2.80	0.60	20	5.4	15.0	0.07	0.1	218	82	136	194	112	82	412	194	218
	07:06	14.1	60	300	37	26		0.16	3.10	0.96	18	11.0	21.0	0.09	0.1	174	48	126	202	128	74	376	176	200
	07:13	11.3	80	230	38	26		0.14	2.80	0.62	11	7.4	16.0	0.08	0.1	139	38	101	226	138	88	365	176	189

* Samples Unpreserved

Units are mg./litre unless otherwise indicated

RUNOFF QUALITY DATA

DATE DY/MO/YR	TIME HR. MN	FLOW c.f.s.	B.O.D	C.O.D	CHLORIDE AS Cl	SULPHATE AS SO ₄	CONDUCTIVITY UMHOS/CM	LEAD AS Pb	TOTAL PHOSPHORUS AS P	DISSOLVED REACTIVE PHOSPHORUS AS P	PHENOLS IN PPB *	NITROGEN AS N				SUSPENDED SOLIDS			DISSOLVED SOLIDS			TOTAL SOLIDS		
												FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS
20/07/76	19:36	22.1	180	753	40	31	365	0.44	6.20	0.98	6	4.4	24.0	0.01	0.2	454	162	292	318	204	114	772	366	406
	19:43	23.8	85	485	29	26	270	0.35	3.40	0.46	5	1.1	13.0	0.01	<0.1	287	120	167	216	162	54	503	282	221
	19:50	22.6	38	304	26	21	230	0.23	2.90	0.16	3	0.4	9.0	0.01	<0.1	193	74	119	182	152	30	375	226	149
	19:56	21.3	22	199	24	18	205	0.18	1.90	0.10	2	<0.1	6.0	<0.01	<0.1	98	25	73	172	150	22	270	175	95
	20:03	16.2	26	183	28	19	215	0.14	1.50	0.02	3	0.2	5.5	<0.01	<0.1	96	31	65	152	130	22	248	161	87
	20:10	12.0	32	159	40	24	300	0.10	1.30	0.02	2	0.4	6.0	<0.01	<0.1	79	16	63	188	170	18	267	186	81
	20:16	9.8	Exh.	Exh.	Exh.	Exh.	305	Exh.	1.40	Exh.	Exh.	Exh.	7.0	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.	Exh.
20/07/76	21:07	49.0	60	294	28	19	240	0.34	2.00	0.16	3	1.3	8.5	<0.01	<0.1	206	86	120	174	124	50	380	210	170
	21:14	60.4	24	292	13	12	140	0.45	2.40	0.08	2	0.5	8.5	0.06	<0.1	221	121	100	104	94	10	325	215	110
	21:21	54.0	18	233	11	9	110	0.28	2.10	0.04	2	<0.1	5.2	0.08	0.2	108	56	52	104	76	28	212	132	80
	21:27	49.5	25	139	11	8	100	0.21	1.20	0.02	2	0.1	4.6	0.06	0.2	126	70	56	62	60	2	188	130	58
	21:34	49.3	20	84	10	7	92	0.17	0.80	0.02	2	<0.1	3.4	0.05	0.3	63	28	35	60	60		123	88	35
	21:41	54.0	18	80	9	7	86	0.15	0.76	0.10	2	0.1	2.6	0.04	0.4	51	15	36	54	38	16	105	53	52
	21:47	54.4	19	139	9	7	84	0.15	0.68	0.02	2	0.2	2.6	0.04	0.4	45	19	26	64	60	4	109	79	30
	21:54	49.0	13	50	10	7	98	0.20	0.48	0.06	2	0.2	2.2	0.04	0.4	38	15	23	66	62	4	104	77	27
	22:01	45.4	12	86	10	7	86	0.09	0.48	0.02	2	0.2	2.2	0.04	0.4	33	12	21	60	54	6	93	66	27
	22:07	41.1	11	66	11	7	86	0.08	0.48	0.02	1	0.3	2.2	0.04	0.4	27	6	21	64	48	16	91	54	37
	22:14	35.3	10	68	11	8	98	0.08	0.60	0.10	2	0.7	2.6	0.04	0.4	26	7	19	70	42	28	96	49	47
	22:21	26.0	13	80	17	10	130	0.04	0.40	0.08	1	0.5	2.2	0.04	0.6	14		14	96	59	37	110	59	51
29/07/76	08:30	17.5	130	403	28	24	320	0.57	2.90	0.26	7	1.9	12.0	0.16	0.6	322	170	152	228	110	118	550	280	270
	08:37	39.2	50	259	27	21	250	4.80	2.10	0.26	6	1.0	7.0	0.14	0.9	187	92	95	138	84	54	325	176	149
	08:43	38.2	70	253	32	21	300	0.28	3.00	0.20	6	1.2	11.0	0.14	0.9	208	88	120	158	108	50	366	196	170
	08:50	27.5	70	291	54	24	365	0.31	2.50	0.22	7	1.5	8.5	0.16	1.0	193	78	115	230	126	104	423	204	219
	08:57	18.8	55	168	21	14	190	0.24	1.70	0.20	5	2.2	7.2	0.10	0.9	103	40	63	120	64	56	223	104	119
	09:03	14.2	42	209	14	11	170	0.30	1.40	0.26	6	2.0	8.0	0.06	0.5	173	88	85	78	56	22	251	144	107
	09:10	13.5	60	226	15	11	160	0.28	2.50	0.56	6	1.8	10.0	0.06	0.5	187	76	111	92	54	38	279	130	149
	09:17	17.0	38	128	25	13	160	0.18	1.40	0.26	4	1.8	5.8	0.06	0.9	104	40	64	62	60	2	166	100	66
	09:23	23.4	22	135	31	16	245	0.16	1.40	0.32	4	2.3	5.6	0.06	1.1	36	12	24	108	96	12	144	108	36
	09:30	29.4	22	85	30	15	210	0.12	1.10	0.42	5	2.9	6.4	0.05	1.1	30	6	24	92	72	20	122	78	44
	09:37	28.2	26	110	25	19	240	0.07	1.10	0.46	8	2.7	6.4	0.05	0.9	20	-	20	96	76	20	116	76	40
	09:43	26.0	20	79	18	15	185	0.06	0.92	0.30	8	1.8	5.0	0.04	0.8	17	-	17	78	52	26	95	52	43
	09:50	54.6	22	68	15	13	165	0.08	0.88	0.22	6	1.5	4.4	0.04	0.7	19	-	19	70	50	20	89	50	39
	09:57	?	20	76	13	14	135	0.06	0.72	0.30	17	0.9	3.8	0.04	0.7	11	-	11	68	61	7	79	61	18

* Samples Unpreserved

Units are mg./litre unless otherwise indicated

RUNOFF QUALITY DATA

DATE DY/MO/YR	TIME HR:MN	FLOW c.f.s.	B.O.D	C.O.D	CHLORIDE AS Cl	SULPHATE AS SO ₄	CONDUCTIVITY UMHOS/CM	LEAD AS Pb	TOTAL PHOSPHORUS AS P	DISSOLVED REACTIVE PHOSPHORUS AS P	PHENOLS IN PPB *	NITROGEN AS N				SUSPENDED SOLIDS			DISSOLVED SOLIDS			TOTAL SOLIDS		
												FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS
31/07/76	09:20	37.7	120	350	40	20	310	0.22	3.80	1.30	13	6.8	17.0	<0.01	<0.1	235								
	09:27	35.2	55	400	21	16	225	0.28	3.30	1.70	8	4.6	12.0	<0.01	<0.1	203								
	09:33	24.8	26	105	25	14	220	Exh.	1.60	0.74	8	4.2	7.5	0.04	0.1	89								
	09:40	17.4	34	120	34	16	280	0.10	1.70	0.68	8	5.9	9.5	<0.01	<0.1	86								
	09:47	13.1	30	130	42	22	345	0.16	1.90	0.94	8	6.8	11.0	<0.01	<0.1	88								
	09:53	18.0	50	155	34	17	243	0.12	1.20	0.28	8	1.2	5.5	0.01	<0.1	68								
	10:00	20.2	18	81	29	15	225	0.14	0.92	0.40	4	3.0	5.2	0.01	<0.1	38								
	10:07	16.9	13	130	29	16	240	0.12	0.88	0.70	4	4.4	5.8	0.12	0.3	26								
	10:13	16.0	15	60	32	16	250	Exh.	1.60	1.30	4	3.1	4.6	0.14	0.2	33								
	10:20	22.3	14	75	23	14	197	0.10	0.84	0.52	4	3.6	5.0	0.08	0.1	42								
	10:27	28.6	16	85	19	16	175	Exh.	0.80	0.36	4	2.7	4.6	0.06	0.1	54								
	10:33	23.8	17	97	21	13	170	Exh.	0.64	0.24	2	1.4	3.2	0.11	0.3	43								
	10:40	24.7	15	80	16	14	165	Exh.	0.92	0.40	4	2.5	4.6	0.10	0.3	52								
	10:47	30.0	13	100	14	13	150	Exh.	0.60	0.28	4	1.7	3.6	0.09	0.3	46								
	10:53	23.6	10	90	20	15	180	Exh.	0.60	0.32	4	1.4	2.6	0.13	0.6	41								
	11:00	16.0	9	70	28	15	225	Exh.	0.48	0.28	4	2.3	3.4	0.18	0.8	26								
	11:07	15.1	15	70	32	17	255	Exh.	0.80	0.24	2	2.3	4.2	0.17	0.1	31								
	11:13	17.9	12	55	25	17	210	Exh.	0.64	0.34	4	2.3	3.8	0.17	0.6	33								
	11:20	22.1	10	65	21	16	170	Exh.	0.56	0.44	8	1.8	3.2	0.15	0.8	17								
	11:27	22.3	8	50	22	16	200	Exh.	0.48	0.32	4	1.0	2.0	0.17	1.1	12								
	11:33	18.4	10	50	27	19	Exh.	Exh.	0.56	0.40	4	1.2	2.4	0.20	1.0	6								
	11:40	26.0	13	35	15	17	144	Exh.	0.76	0.42	4	1.6	3.8	0.15	0.5	36								
	11:47	24.2	8	60	16	16	136	Exh.	0.64	0.38	Exh.	1.1	2.6	0.15	0.7	28								
	11:53	17.8	12	75	27	22	160	Exh.	0.68	0.46	Exh.	1.4	3.2	0.24	0.5	23								
13/08/76	16:24	120.0	100	413	18	10	225	0.42	4.40	0.26	5	0.3	13.0	0.01	0.1	642								
	16:30	92.0	50	240	12	10	146	0.40	2.40	0.24	<1	0.5	7.7	0.02	0.1	450								
	16:37	48.0	60	283	14	10	160	0.36	3.40	0.28	1	1.0	11.0	0.01	0.1	460								
	16:44	21.0	18	151	27	16	225	0.16	1.50	0.20	<1	1.0	4.8	0.09	0.3	221								
	16:50	14.0	17	99	36	18	265	0.12	1.60	0.68	<1	1.2	4.0	0.22	0.6	134								
	16:57	10.0	16	112	49	24	335	0.08	1.10	0.26	<1	1.1	4.0	0.22	0.3	105								
28/08/76	16:22	110.0	130	755	25	25	305	0.80	5.20	0.68	13	1.8	18.0	0.01	<0.1	635								
	16:28	96.0	36	250	12	27	205	0.54	2.90	0.40	4	1.6	9.0	0.12	<0.1	330								
	16:35	105.0	41	332	11	27	220	0.52	2.60	0.50	3	1.2	8.5	0.08	<0.1	350								
	16:42	206.0	20	140	9	21	150	0.34	1.60	0.20	2	0.7	6.4	0.12	0.4	175								
	16:48	?	16	112	8	20	140	0.24	1.20	0.12	2	0.9	4.6	0.15	0.4	110								
	16:55	185.0	20	120	9	20	130	0.22	0.96	0.02	2	<0.1	4.2	0.06	<0.1	100								
	17:02	208.0	11	86	7	19	130	0.22	0.60	0.04	3	0.3	2.6	0.23	0.8	86								
	17:08	140.0	11	86	6	15	112	0.20	0.68	0.06	3	<0.1	2.8	0.09	0.5	115								
01/09/76	01:39	59.0	160	743	30	22	287	Exh.	3.80	0.58	7	2.6	15.0	0.53	0.3	330								
	01:46	53.0	60	324	15	18	200	0.25	2.10	0.26	5	1.2	7.5	0.16	1.5	195								
	01:52	34.0	48	170	17	16	180	0.14	1.80	0.20	5	1.2	6.4	0.14	1.6	135								
	01:59	17.0	36	128	24	17	195	0.14	1.20	0.20	5	1.0	5.2	0.11	1.9	85								
	02:06	15.0	22	87	23	15	185	0.14	0.76	0.12	4	0.7	3.4	0.08	2.0	75								
	02:12	20.0	18	70	15	13	150	0.12	0.60	0.14	3	1.0	3.8	0.07	1.7	45								
	02:19	20.0	15	70	18	13	150	0.06	0.40	0.16	3	1.0	2.8	0.07	1.7	25								
	02:26	14.5	12	59	21	14	175	0.07	0.48	0.12	2	0.8	2.2	0.07	1.9	20								
	02:32	10.0	11	64	36	18	255	0.06	0.28	0.12	2	0.7	1.8	0.06	2.4	25								

* Samples Unpreserved

APPENDIX E
DRY WEATHER FLOW QUALITY DATA

Units are mg./litre unless otherwise indicated

DRY WEATHER FLOW QUALITY DATA

DATE DY/MO/YR	TIME HR MN	FLOW c.f.s.	B.O.D	C.O.D	CHLORIDE AS Cl	SULPHATE AS SO ₄	CONDUCTIVITY UMHOS/CM	LEAD AS Pb	TOTAL PHOSPHORUS AS P	DISSOLVED REACTIVE PHOSPHORUS AS P	PHENOLS IN PPB *	NITROGEN AS N				SUSPENDED SOLIDS			DISSOLVED SOLIDS			TOTAL SOLIDS		
												FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS
23/06/77	10:30		240	530	171	91	1245	0.10	7.20	3.70	24	19.0	33.0	<0.01	<0.1	201								
	11:40		150	320	133	76	1045	0.06	5.80	3.80	12	19.0	28.0	<0.01	<0.1	132								
	12:28		110	280	121	77	940	0.04	4.90	3.20	21	17.0	25.0	<0.01	<0.1	122								
	13:30		70	280	118	67	910	0.04	5.60	3.50	21	13.0	22.0	<0.01	<0.1	120								
	14:35		110	210	142	61	1065	<0.02	6.90	2.20	10	17.0	29.0	<0.01	<0.1	81								
	15:28		110	220	133	65	1015	<0.02	3.70	2.30	13	16.0	22.0	<0.01	<0.1	93								
	16:32		100	190	141	63	1035	<0.02	3.50	2.20	9	17.0	22.0	<0.01	<0.1	74								
	17:31		90	150	151	62	1025	<0.02	3.00	1.70	3	16.0	22.0	<0.01	<0.1	69								
	19:20		180	290	152	64	1060	<0.02	4.40	2.40	15	18.0	28.0	<0.01	<0.1	131								
	20:05		160	290	164	67	1080	<0.02	3.70	1.70	10	13.0	23.0	<0.01	<0.1	118								
	21:00		130	290	150	64	970	<0.02	3.90	2.20	11	16.0	24.0	<0.01	<0.1	93								
05/07/77	09:30		180	629	130	60	1010		5.40	2.30	2	24.0	33.0	0.01	<0.1	127								
	10:31		130	353	131	69	1005		4.80	3.10	1	20.0	30.0	0.01	<0.1	90								
	11:30		92	378	134	78	1015		6.00	3.90	1	15.0	25.0	0.01	<0.1	89								
	12:30		120	316	140	81	1030		4.40	2.40	1	13.0	22.0	0.01	<0.1	86								
	13:28		114	237	142	69	1005		3.40	2.00	1	11.0	16.0	<0.01	<0.1	81								
	14:29		75	255	132	69	960		3.40	2.00	1	12.0	19.0	<0.01	<0.1	59								
	15:30		85	247	136	67	985		4.40	3.10	<1	13.0	19.0	<0.01	<0.1	68								
	16:28		85	257	130	62	965		3.30	1.70	<1	13.0	20.0	<0.01	<0.1	80								
	17:30		80	264	138	67	965		2.80	1.40	<1	12.0	18.0	<0.01	<0.1	59								
	18:29		140	367	140	67	970		3.80	2.10	2	15.0	24.0	<0.01	<0.1	100								
	19:31		150	528	143	70	950		4.80	2.60	3	13.0	24.0	<0.01	<0.1	126								
	20:32		115	378	143	69	1000		4.80	2.60	1	15.0	25.0	<0.01	<0.1	103								
	21:32		78	288	138	72	960		3.80	1.90	<1	14.0	22.0	<0.01	<0.1	86								
	22:30		85	241	141	62	995		6.60	4.80	<1	17.0	25.0	<0.01	<0.1	65								
	23:30		100	253	120	63	915		4.40	2.70	<1	20.0	28.0	<0.01	<0.1	74								
06/07/77	00:31		50	168	137	56	945		3.00	1.70	<1	17.0	25.0	<0.01	<0.1	44								

*.Samples Unpreserved

Units are mg./litre unless otherwise indicated

DRY WEATHER FLOW QUALITY DATA

DATE DY/MO/YR	TIME HR MN	FLOW c.f.s.	B.O.D	C.O.D	CHLORIDE AS Cl	SULPHATE AS SO ₄	CONDUCTIVITY UMHOS/CM	LEAD AS Pb	TOTAL PHOSPHORUS AS P	DISSOLVED REACTIVE PHOSPHORUS AS P	PHENOLS IN PPB *	NITROGEN AS N				SUSPENDED SOLIDS			DISSOLVED SOLIDS			TOTAL SOLIDS		
												FREE AMMONIA	TOTAL KJELDAHL	NITRITE	NITRATE	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS	DRIED	ASHED	LOSS
19/10/77	14:56†		138	336	107	67	850		4.63	1.50	3	9.7	20.0	<0.01	<0.1	88								
	14:56		140	336	105	64	870				3					89								
	16:36		84	245	124	67	895				3					23								
	17:17		102	274	100	64	800				4					21								
	17:19		122	241	102	64	795				3					14								
	18:21		205	314	105	64	855				6					164								
	19:23		230	418	117	97	940				7					61								
	20:25		175	366	120	69	910				6					118								
	21:27		120	110	112	59	845				5					93								
	22:29		86	481	100	64	860				4					34								
	23:31		185	266	102	61	865				5					24								
	20/10/77 00:33		170	145	115	56	895				3					16								
	01:35		30	141	139	61	935				1					10								
20/10/77	02:37		18	59	146	59	950				1					13								
	03:39		22	67	132	53	885				1					6								
	04:41		19	94	139	56	905				1					8								
	05:43		19	81	134	56	930				1					10								
	06:45		42	215	120	59	1015				2					70								
	07:47		270	295	107	64	1045				4					145								
	08:49		180	463	105	72	1050				14					138								
	09:56		170	Exh	Exh	Exh	940				Exh					Exh								
	10:00†		155	358	107	85	965		4.40	3.00	7	24.4	60.0	<0.01	<0.1	117								
	10:00†		160	338	102	85	950		6.60	3.10	8	25.6	50.0	<0.01	<0.1	110								
	10:51		240	319	98	72	870				6					84								
	20/10/77 17:27†		160	383	123	60	990		4.50	2.00	31	19.0	30.0	<0.01	<0.1	150								
	17:27		95	538	111	67	940		4.10	2.00	6	17.0	28.0	<0.01	<0.1	140								
21/10/77	18:29		Exh	396	100	Exh	920		6.70	3.70	15	16.0	25.0	<0.01	<0.1	295								
	19:31		Exh	540	125	Exh	970		6.50	2.50	21	16.0	39.0	<0.01	<0.1	Exh								
	20:33		110	279	111	Exh	880		3.90	2.00	3	13.0	23.0	<0.01	<0.1	140								
	21:35		95	331	114	63	910		3.80	2.10	4	16.0	24.0	<0.01	<0.1	135								
	22:37		70	265	288	80	1600		4.50	2.60	4	23.0	32.0	<0.01	<0.1	96								
	23:39		50	308	108	61	900		3.90	2.00	3	23.0	31.0	<0.01	<0.1	125								
	00:41		26	139	113	Exh	910		3.00	1.50	4	18.0	23.0	<0.01	<0.1	335								
	01:43		16	100	117	57	860		1.80	1.10	2	14.0	16.0	0.45	1.1	74								
	02:45		16	50	118	54	850		1.40	0.80	2	10.0	13.0	0.18	2.0	33								
	03:47		20	37	139	57	950		1.00	0.54	2	8.8	11.0	0.30	2.3	36								
	04:49		8	37	134	56	890		1.20	0.90	4	12.0	14.0	0.15	2.9	30								
	05:51		7	41	130	53	940		1.60	0.96	2	13.0	16.0	0.17	2.5	15								
	06:53		45	135	122	58	1070		4.40	2.60	3	32.0	40.0	0.40	0.8	195								
	07:55		Exh	390	99	Exh	1020		7.20	3.60	4	35.0	50.0	0.02	0.1	240								
21/10/77	08:57		100	396	108	58	930		5.60	2.30	9	10.0	22.0	<0.01	<0.1	155								
	09:59		95	379	98	80	920		5.10	2.60	5	16.0	27.0	<0.01	<0.1	155								
	11:01		70	347	110	74	940		4.40	2.00	4	13.0	24.0	<0.01	<0.1	175								
	12:03		130	547	114	72	1020		7.00	3.50	5	23.0	38.0	<0.01	<0.1	220								
	14:15†		110	354	108	55	910		5.60	2.40	25	11.0	22.0	<0.01	<0.1	115								

* Samples Unpreserved

† Manual Sample



96936000009279